TELESCOPE MAKING 30

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The magazine *for*, *by*, and *about* telescope makers!

Summer 1987

Telescope Making

The magazine *for, by,* and *about* telescope makers!

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Cover: Ronald Hill observes M-13 through his 17.5-inch Dobsonian reflector. Photo taken by available light using a Litton M911 pocket scope image intensifier, Tri-X, 1/4-second hand-held.

Editorial

Whether thirty issues represents a milestone or not, we've reached it, and it's worth a word or two. *Telescope Making* has come a long way since the first skinny little issue, but one thing has remained constant: the devotion and appreciation of its readership. Without your outspoken desire for a magazine about telescopes and telescope maing, without the constant flow of articles you have provided me, and without your willingness to put up with our irregular publishing schedule, this little magazine could never have lasted these last nine years. We have accomplished something with *TM*, you and I, something that doesn't often happen in the world of commercial publishing. We have created a journal that supports the free exchange of ideas among a small but influential band of thinkers. And that's what 's made it worth all the effort to me.

Since we began publishing, the technology has come a long way. This issue, with the exception of the Letters column, was conceived almost entirely on the screen of a Mac+, nurtured by Word, midwived by ReadySetGo, birthed by our faithful Laserwriter+.It's okay, but we've still got a way to go. With each future issue,we'll try to whip these programs and machines into little better performance.

– RB

Letters

Apo Club Forming

Dear Richard — I am forming an "Apo Club" to make a bulk purchase of glass for apochromatic refractor objectives. The design uses Ohara FK01 and FK16 from Glass Fab, Inc. I have been quoted the following prices for a molded lens set, quantity of eight: 6-inch $717; 7-inch $1140; 8-inch $1635. For a quantity of twelve, prices quoted are: 6-inch $607; 7-inch $980; 8-inch $1418.

Please write expressing your interest before September 15. Checks will be returned, of course, if we unable to place a bulk order.

John Gregory
Route A Box 56F
Dripping Springs, TX 78620

Good/Bad Products

Dear Sir / With this correspondence I wish to generate some enthusiasm amongst the editorial staff of *Telescope Making* towards providing a regular column reviewing commercial astronomical equipment. The basic goal is to help guide TMs in the purchase of fine quality products. Photography magazines test cameras and film; automobile magazines test and review cars. I would hope the same could be done for astronomical equipment.

My experience indicates that such a service would be of substantial benefit to all amateur astronomers. I work for an optical company and have access to optical equipment, which allows me to test optical products for quality relative to advertised claims. However, very few TMs or groups have such an advantage and must rely on either word of mouth or manufacturer's claims. The latter can be risky at times.

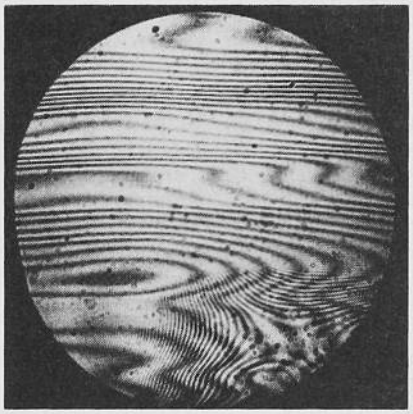
Examples abound which illustrate the need for an independent review of astronomical products to truthfully discuss the performance of a given product. Have you ever thought what harm Tasco's infamous low cost telescopes (those with an "aperture stop" half the size of the objective lens immediately behind the actual objective) do to the popularity of astronomy? It is certainly a sad joke on the novice amateur astronomer who purchases one of these scopes.

Or consider a product I recently ordered from Thousand Oaks Optical, a "precision" glass solar filter that had such severe amounts of aberration as to render it totally unusable, as demonstrated by the enclosed interferogram.

On the positive side, data Lumicon supplied with its light-pollution filters was as accurate as our spectrophotometer could check, as were their claims for the filters' performance, in my opinion. Many other examples of good and bad performance could be cited, but perhaps the above examples are sufficiently illustrative.

I feel we all would be happy to read about products that perform well and equally thankful in being alerted to poor performance. I would hope you will consider such a service. Also, I suspect many professionals would be glad to help review and/or test manufacturer's products. I am sure all concerned would benefit from this pursuit.

David E. Stoltzmann
368 N. Ninth Street
Bayport, MN 55003



Ball-Scope Base

Dear Sir / Please find enclosed a photo of my telescope base, which I had promised to send you quite a while ago. Sorry for the delay, but I've been in the process of moving for the past several months and I'm just getting organized.

Tom O'Brien
206 Wintergreen Hill Dr.
Painesville, OH 44077

Need Some Small Parts?

Dear Sir / Although I have all copies of *TM*, I have failed to find mentioned a company known as Small Parts, Inc. of Miami, Florida.

I received my copy of Catalog #10 yesterday, after requesting it upon first learning of the company after reading about it in Mr. Peter Dechert's monthly column in *SHUTTERBUG*.

I have returned a request card to Small Parts to have the company send you a copy of its catalog. You'll find what great delights it contains in its 176 pages rod, bar, and sheet Teflon for those Dobsonian buffs, fasteners made of nylon, brass, stainless steel, brass, titanium, or Delrin gears, brass racks and pinion gears. I could go on and on.

In my youth I recall the time and frustration we all spent at the Los Angeles Astronomical Society, me especially, trying to find all the little goodies for my telescopes.

Anyhow, I'm sure your readers will be happy to know about Small Parts, Inc. By the way, I look forward to meeting you, possibly at the next Riverside.

Pete Hallock
P.O. Box 4378
Laguna Beach, CA 92652

— We have mentioned Small Parts several times in past issues, but there's no harm in doing so again. Its service has been fast and efficient when I've ordered from the company, and the prices are quite reasonable. The address is: 6891 N.E. Third Avenue, P.O. Box 381736, Miami, FL 33238-1738.

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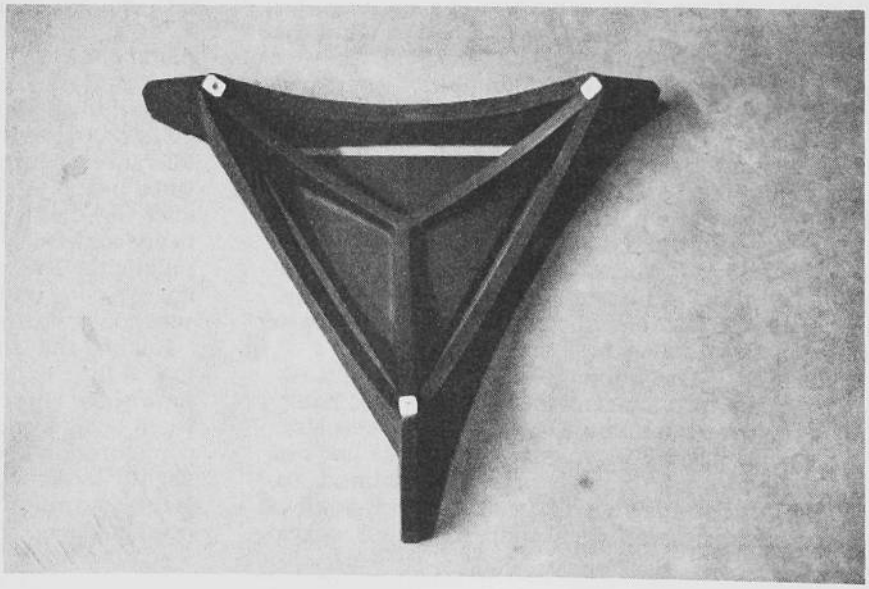


A New Wide-Field All-Spherical Telescope

Over the years I have designed and made a number of telescope and in the process have developed a special fondness for those designs that use only spherical surfaces (see *TM#2*). Maybe it is blasphemy, but I have frequently found aspheric mirrors to be lumpy, astigmatic (i.e. not true surfaces of revolution), and just plain hard to make accurately. Spheres, on the other hand, nearly always come out just as planned and are certainly easier to make and test.

Telescopes that use only spherical surfaces are usually some form of catadioptric like the Maksutov (*S&T*, September 1975). The only objection I have to a Maksutov is the cost of the glass for the thick corrector and the close tolerances on its short radii. Fortunately, J. L. Houghton showed in his 1944 patent #2,350,112 that an afocal (i.e. essentially infinite focal length) doublet lens can be used in a manner similar to a Maksutov corrector or Schmidt plate. One example of such an application is found in "The Houghton Camera" by R. A. Buchroeder, published in *TM#8*. This modification can eliminate the two drawbacks mentioned while retaining the wide field performance.

Fabrication of an afocal corrector is easy. The lenses have long radii, forgiving tolerances, modest central thickness, and are of the same type of glass, usually a borosilicate crown. Actually, what I had in mind was developing a design that would use the plate glass tools then found in many mirror making kits. I examined several pieces of this type of plate glass 3/4-inch thick or thicker and found them relatively free of internal strain. I seem to remember reading someplace that the corrector for the 48" Schmidt camera on Palomar was made from common plate glass. When it came to building my own telescope, I did not use plate glass because I was lucky enough to be around when a local glass distributor went out of business and sold me two lovely, thick pieces of BK-7 crown glass 12 inches in diameter for a song.

The telescope design parameters given are for a 10-inch clear aperture. I picked this size because I had built a classical Cassegrainian telescope of this size about ten years ago (*S&T*, August 1973), and I had nearly all of the mechanical parts necessary on hand. To find specifications for any other size, simply scale all the construction parameters radii, thickness, spacing, diameter linearly (i.e., for a 6" use 0.6, 8" use 0.8, 12" use 1.2).

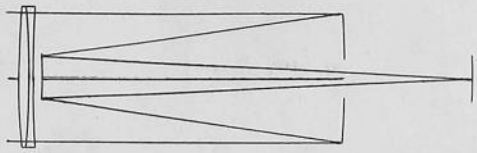
In the process of investigating the properties of all spherical Cassegrainian telescopes with Houghton correctors (*Applied Optics*, May 15, 1974) I found that it would be possible for each lens surface of the corrector to become the grinding tool and test plate for one of the others; this is he case in the specifications given in this article.

The prescription and tolerance data are rather self-explanatory, but a few comments are in order. The corrector is specified as Schott BK-7, but other light crown glasses, BSC-2, including plate window glass will work. The separation between the R2 and R3 surfaces is 0.080 inches, but if 11-inch diameter glass blanks are used, then edge contact of these surfaces will automatically space them correctly.

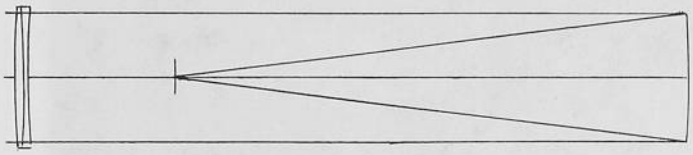
The secondary mirror produces an obstruction of 12% and is only slightly oversize to accommodate the off-axis rays so that vignetting increases to a total of 23% at the full field of two degrees. A little vignetting within the field is practically unnoticeable, but increasing the secondary size to eliminate this hurts resolution everywhere in the field.

During the building of this instrument I had the good fortune to have a friend who had the equipment to diamond generate all the optics for me, saving all the mess and time of rough grinding. Fine grinding could begin immediately using 25-micron grit, and since the glass was generated, wedge was well within acceptable tolerances. I found I had to be careful in last stages when using 5-micron grit because of its tendency to stick together if the wet ran too dry. My rule was to never completely break down a fine grit charge before pulling the lens off for a new wet. At this time I also made a concave test glass for later testing of the convex secondary mirror.

Holding the lenses during grinding and polishing took a little experimentation. The biconvex lens must have some type of holder to prevent it from rocking when being worked with the tool or lap on top. The configuration I settled on was an aluminum ring slightly larger than the lens. The shorter radius surface was covered with Saran Wrap and used to mold a bead of silicon RTV adhesive on the lip of the ring.



CASSEGRAINIAN VERSION



NEWTONIAN—CAMERA VERSION

When it was dry, I trimmed off the excess protruding above the edge of the lens and peeled the Saran Wrap off the lens. The ring could now be used to support either a positive or a negative lens without the fear of introducing astigmatism into the surface.

I had always wanted to build a polishing machine, and this project gave me a good excuse. The machine is conventional in design, and its construction was greatly simplified by having some of the important pieces rescued from a junked commercial polisher. I ground a notch into the edge of the biconvex lens. This engaged a pawl that prevented it from rotation during polishing. This was not necessary on the negative lens as it did not tend to rotate in polishing.

The difference between success and failure in making optics is the quality of the test method. Over the years I have probably spent as much effort upgrading my test setup as I have in making optics. The evolution has been from the usual Ronchi grating and Foucault tester to a laser interferometer. Lasers, at least the helium-neon variety, are not really all that expensive. I bought mine about 8 years ago for $99, but unfortunately they have gone up in price since. After using a laser for a while, I am too spoiled to go back to any other way.

A spherical-wave interferometer is simple to construct, and gives an instant picture of the wavefront produced by a surface or an entire telescope without subjective interpretation and messy data reduction. Although I was worried about the stability of using an interferometer made out of wood (and interferometers are famous for being vibration sensitive), wood has good damping properties. I mounted the test apparatus on partially inflated trailer inner tubes; it allows a single interference fringe to be held in the aperture for a nimute or so, more than sufficient for my needs. By the way, a great book for information on interferometers, and nearly any other type of optical testing as well, is **Optical Shop Testing**, edited by D. Malacara.

An important feature of the corrector lenses in the design is that they can be tested interferometrically without an interferometer by placing them on each other and using the Newton's-Ring test. All you need is a ordinary fluorescent light; the shop lamp in my garage woks well. In the specifications I have given the tolerances on the convex surfaces in interference

Newtonian Version Specs

Clear aperture	10.0
Focal length	40.612
F/#	4.0
Full field of view	4.0 degrees

POSITIVE CORRECTOR LENS

Material	Schott BK7
Diameter	11.0
Clear aperture	10.5
R1 (convex)	60.987 (match R3 to 4 fringes)
Center thickness	0.700 +/- 0.010
R2 (convex)	-89.787 (match R4 to 4 fringes)
Lenses spaced by edge contact	

NEGATIVE CORREECTOR LENS

Material	Schott BK7
Diameter	11.0
Clear aperture	10.5
R3 (concave)	-60.987 +/- 0.63
Center thickness	0.320 +/- 0.010
R4 (concave)	89.787 +/- 1.81
Airspace to primary	51.688 +/- 2.00

PRIMARY MIRROR

Diameter	10.0
R5 (cocave)	-80.786 +/- 1.21
Back focal distance	-40.236

IMAGE SURFACE

Diameter at full field	2.84
Best fit radius	-46.491

Cassegrain Version Specs

Clear aperture	10.0
Focal length	105.214
F/#	10.52
Full field of view	2.0 degrees

POSITIVE CORRECTOR LENS

Material	Schott BK7
Diameter	11.0
Clear aperture	10.5
R1 (convex)	60.987 (match R3 to 4 fringes)
Center thickness	0.700 +/- 0.010
R2 (convex)	-89.787 (match R4 to 4 fringes)
Lens spaced by edge contact	

NEGATIVE CORRECTOR LENS

Material	Schott BK7
Diameter	11.0
Clear aperture	10.5
R3 (concave)	-60.987 +/- 0.63
Center thickness	0.320 +/- 0.010
R4 (concave)	89.787 +/- 1.81
Airspace to primary	24.350 +/- 1.22

PRIMARY MIRROR

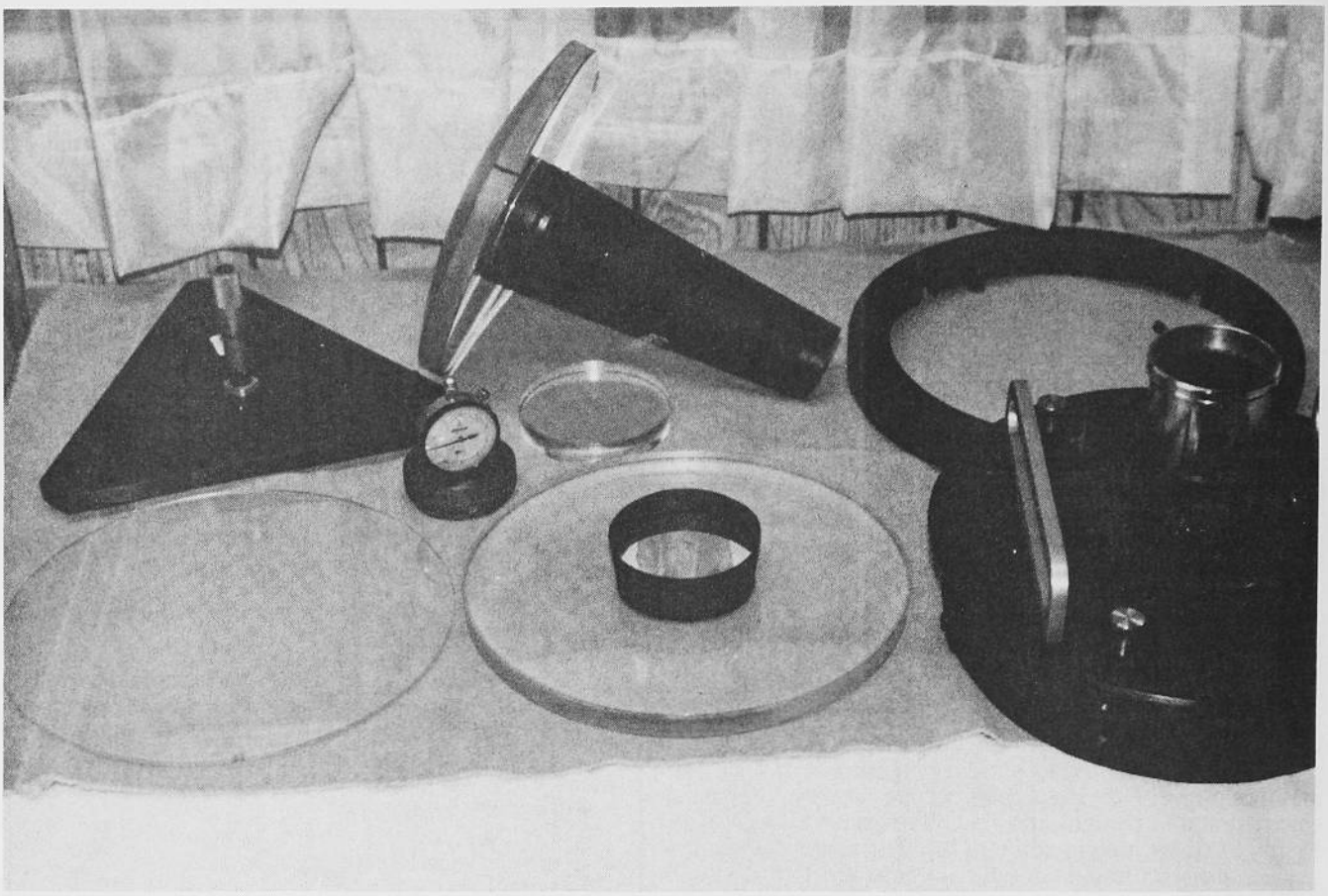
Diameter	10.0
Hole diameter	3.0
R5 (concave)	-70.000 +/- 0.70
Airspace to secondary	-23.687 +/- 0.05

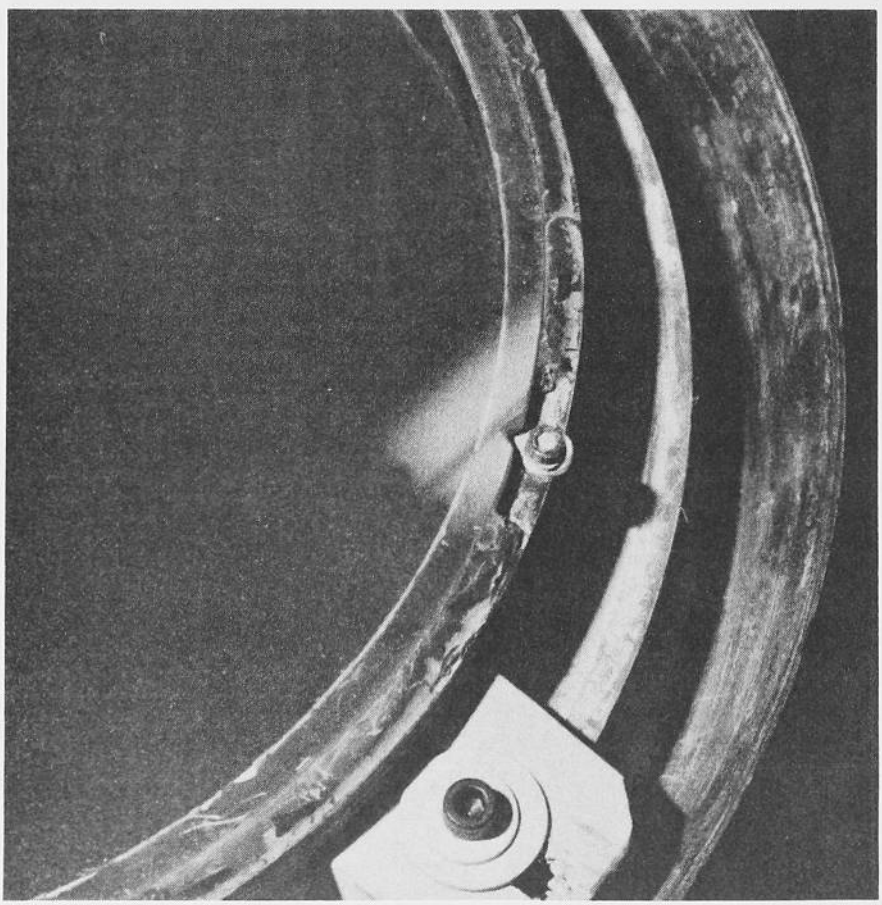
SECONDARY MIRROR

Diameter	3.00
R6 (convex)	-33.853 +/- 1.55
Back focal length	33.665

IMAGE SURFACE

Dimaeter full field	3.67
Best fit radius	-28.474



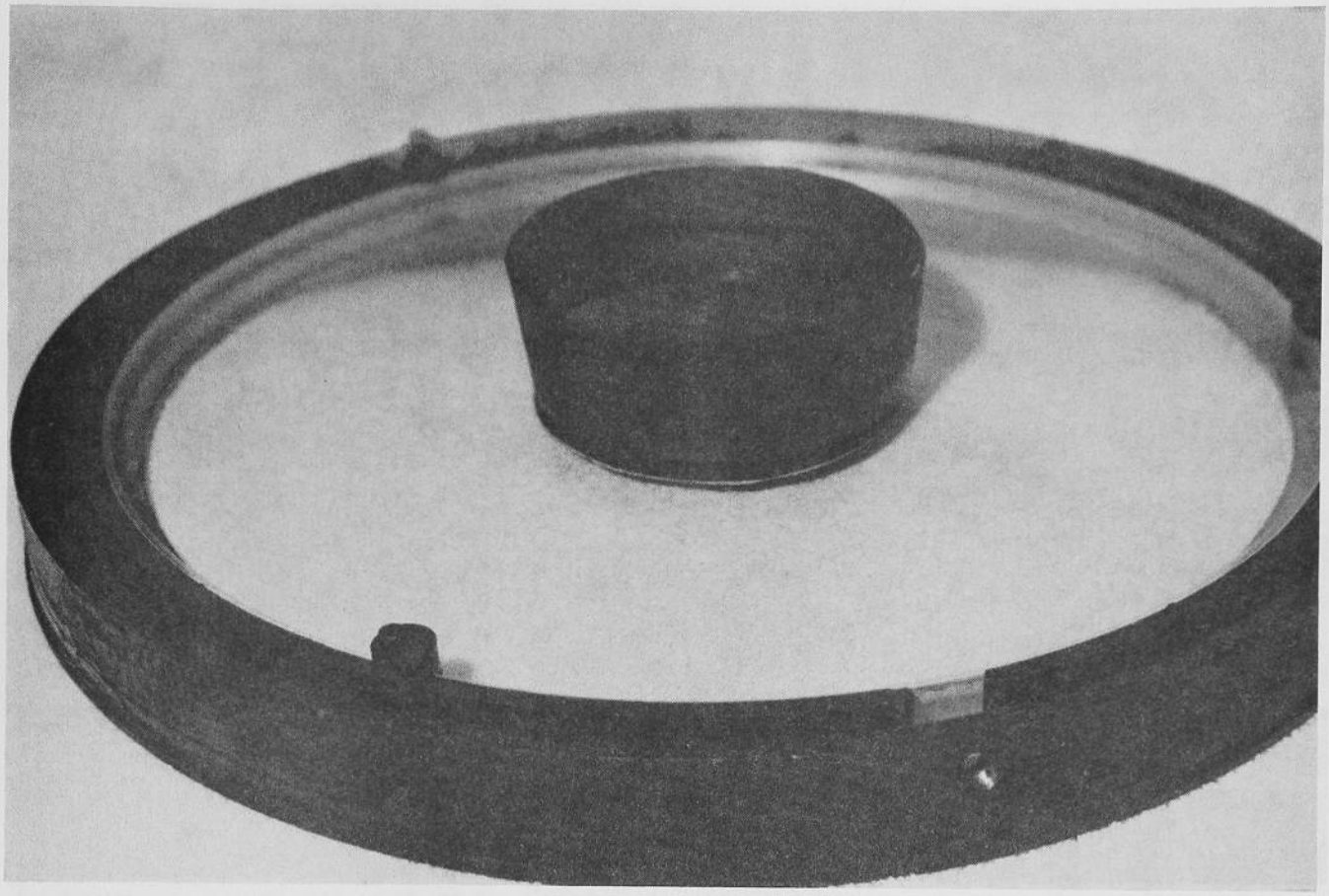


***Above left**: All of the optical and some of the mechanical parts of the Cassegrain version of the telescope. At left are two spherometers used during construction; in the foreground are the elements of the corrector lens ; and in the right foreground, the backplate asembly with its oversize (2.625-inch) focus tube.*

***Above right**: The corrector cell is made from one-inch thick PVC plastic cut using a router with a circle-cutting attachment. The mating holes in the fiberglass telescope tube were slotted to provide tilt adjustment for the corrector/ secondary mirror assembly.*

***Lower left:** The positive element of the corrector lens mounted on the polishing machine. It was necessary to grind a notch into the edge of this element to prevent it from rotating during polishing.*

***Right, below**: Centering the secondary mirror on the negative corrector element using a dial indicator. The spindle was rotated by hand. Center has been achieved when reflection from the surafces of both elements and the secondary are stationary during rotation.*



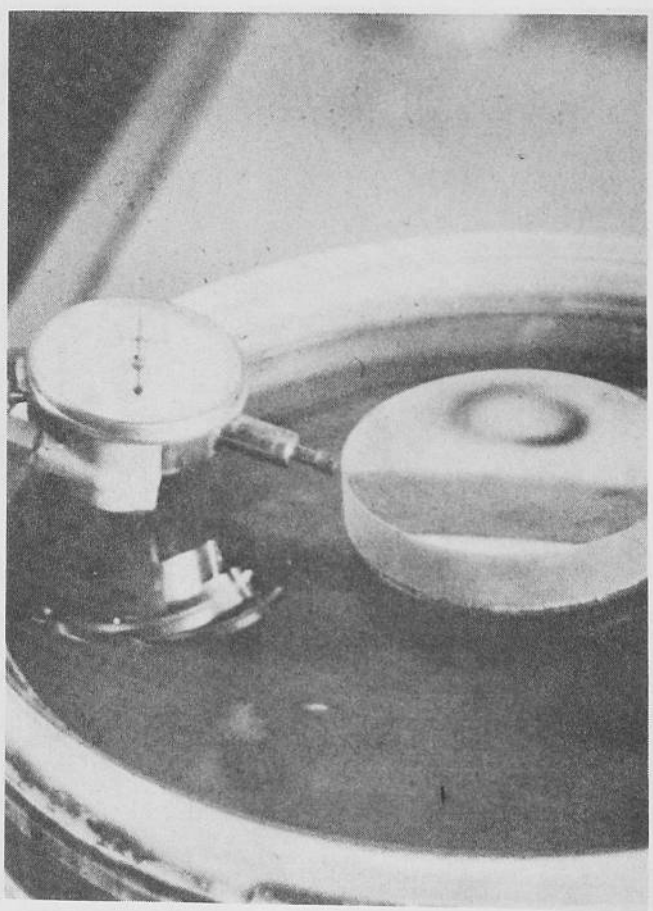
fringes. The concave surfaces, which are Foucault-tested, serve as a test surfaces for the convex ones. In this orientation the focal length of the two lenses together is over 1500 feet: essentially an aberraton-free window. Accompanying diagrams and explanation give test methods for these lenses.

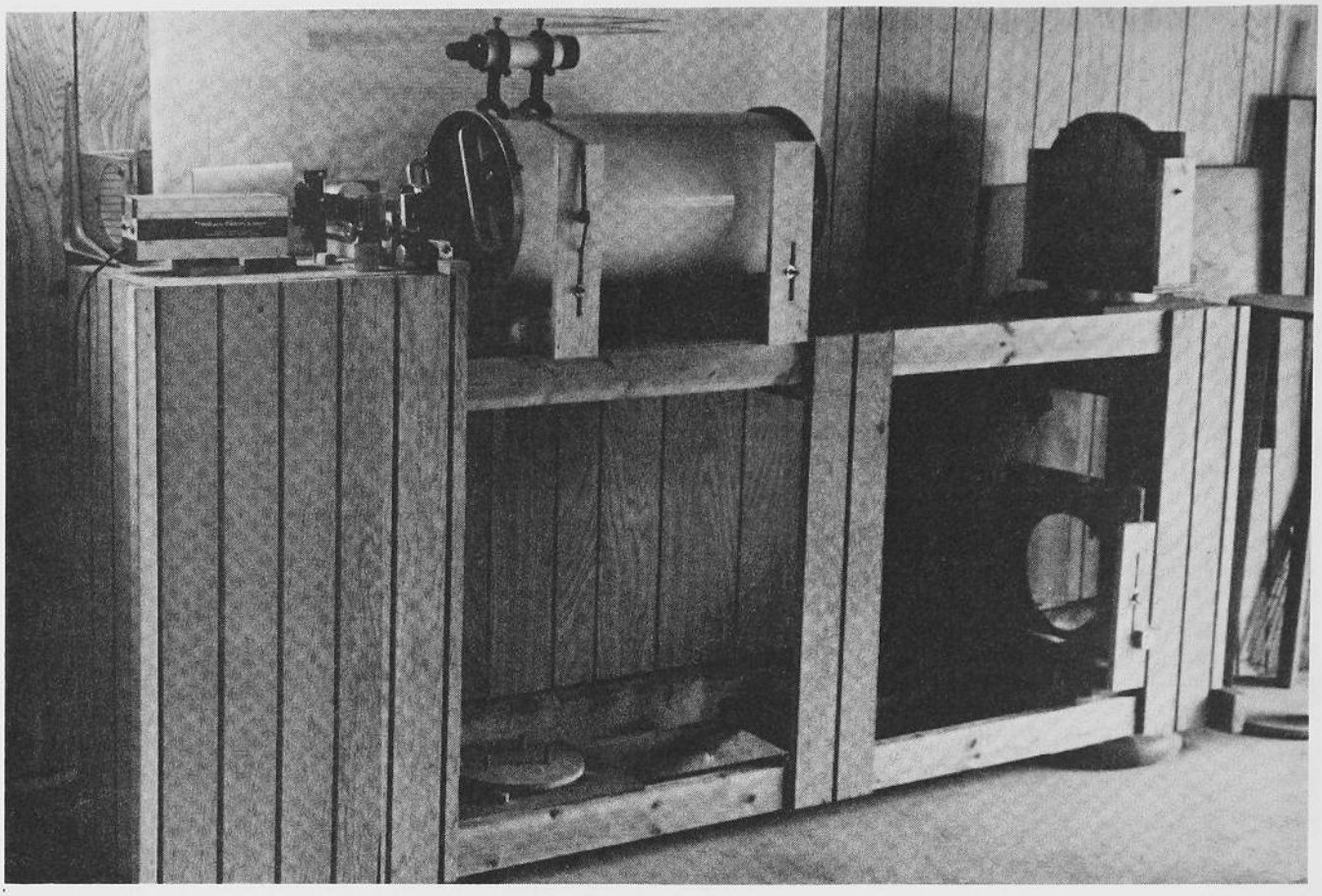
The accompanying interferogram is the whole telescope in double pass, using an autocollimating flat. A flat is, without question, a big help even for the more mundane things like tweaking up the alignment. However, not being able to borrow a flat is not too serious a problem because the entire optical system is composed of readily testable spherical surfaces which can be made to great accuracy without superhuman patience.

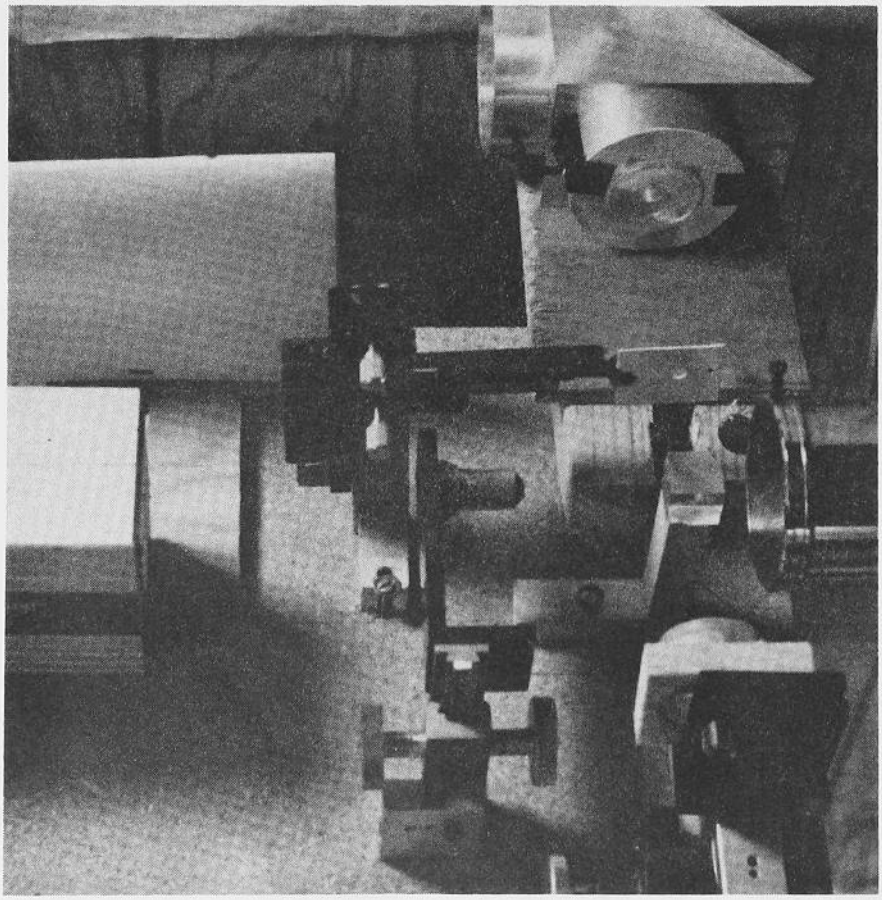
Cassegrain baffles through the primary and on the secondary are just about mandatory to prevent loss of contrast from stray light flooding the image plane. Mine are made out of sheet Mylar stiffened with bent wire rings and painted flat black. A careful scale drawing of the telescope and tracing a couple of rays will show how to size the baffles (see *TM#20*).

The corrector lenses are not anti-reflection coated, yet I have not seen ghost reflections even with very bright objects like Jupiter or Venus. This is most likely due to the absence of near-normal-incidence surfaces like the corrector of a Schmidt plate, which acts like an autocollimating flat.

For visual use the telescope has so far been limited by the atmosphere, and I have yet to take advantage of its photographic potential. Since the planets are my main observing interest, I am still hoping that one night soon the Silicon Valley skies will open up and provide me with sub-arcsecond seeing to challenge the optics.



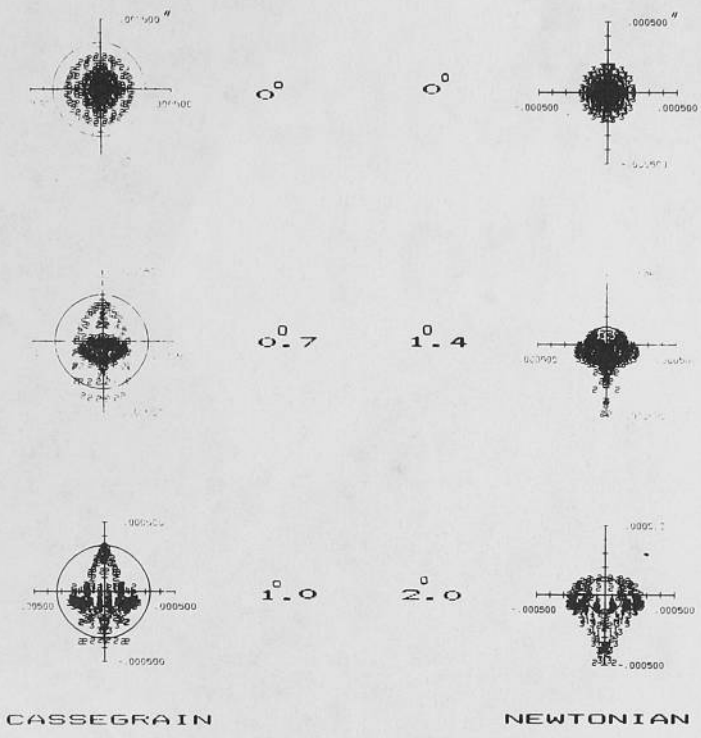




Above: *The laser interferometer and telescope shown on the eight-foot wooden optical bench. The entire optical bench is supported by inner tubes for small trailer tires. The telescope is supported in a cradle that can be adjusted in both position and tilt; at the right end of the table is a 12.5"-diameter autocollimation flat mounted on an adjustable tilt stage. For interference testing, the telescope mirrors and test flat must be aluminized. The holder stored in the base is used for testing corrector and other optical elements.*

Left: *The details of the interference tester. The metal box at left is the head of the 0.5-milliwatt helium-neon laser. A 20x microscope objective diverges the laser beam before it is split by the small beam-splitter cube. One beam enters the telescope, strikes the autocollimating flat, and returns to the cube. The other beam goes to a spherical mirror (bottom right) and returns to interfere with the beam exiting the telescope. A small lens mounted on the star diagonal projects the combined beams to a ground glass screen out of the frame to the left. The white card aids alignment.*

Superior Performance Seen in Spot Diagrams



These computer-generated spot diagrams illustrate the quality of the optical performance of both versions of the telescope at three different field positions, measured in degrees from the optical axis. The ray intercepts at the image surface for light with wavelengths of 588nm (yellow), 486nm (blue), and 656nm (red) are represented by the numbers 1, 2, and 3 respectively. The ray tracing data ignores the effects of diffraction, but the diameter of the first dark ring in the classical Airy pattern for red light is shown by the circles drawn on the spot diagram. Optical systems which can put nearly all their spots inside such a ring are generally considered to be diffraction limited. This condition is better satisfied by the Cassegrain version, for which superior resolution at magnification is a must, especially for planetary observations.

A rather natural question to ask would be if the corrector from the Cassegrain could be used with some other spherical mirror to make a super wide field, low focal number camera (similar to a Schmidt). The drawing and performance data I have included shows that the answer is an emphatic yes! Notice that the optimum location for the corrector is inside the mirror's center of curvature (where a Schmidt corrector would be put) giving a reasonably compact configuration. The camera version, while diffraction-limited on axis, is no longer so at the full field of 4 degrees. It is, however, still light-years ahead of a classic Newtonian RFT of the same focal number. If the camera is used with some fine-grain, contrasty film like Kodak High Contrast Copy film, the system will resolve 350 lines per mm on axis and 117 lines per mm (or 1.8 arc seconds) at full field. This includes the obscuration effects of a centrally mounted 3-inch diameter film holder as well as the limitations of the film. The camera could also be used in a Newtonian form but the diagonal mirror would have a minor axis of 4.1 inches to get full access to the field, and additional loss in contrast would result.

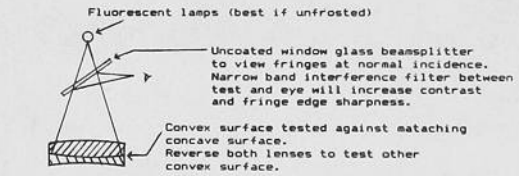
The optical performance of these designs is shown by the spot diagrams. The Cassegrainian is clearly diffraction-limited over a remarkable two-degree field of view and yields a 3.67" diameter image plane.

Robert D. Sigler
10251 Vicksburg Drive
Cupertino, Calif. 95014

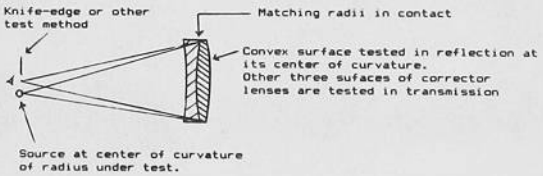
■

Null Testing the Corrector

I. INTERFERENCE (CONTACT) TEST

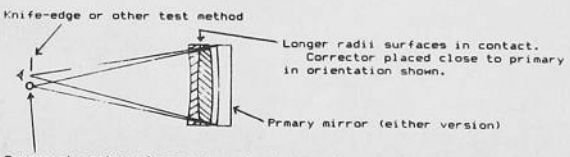


II. CENTER OF CURVATURE TEST



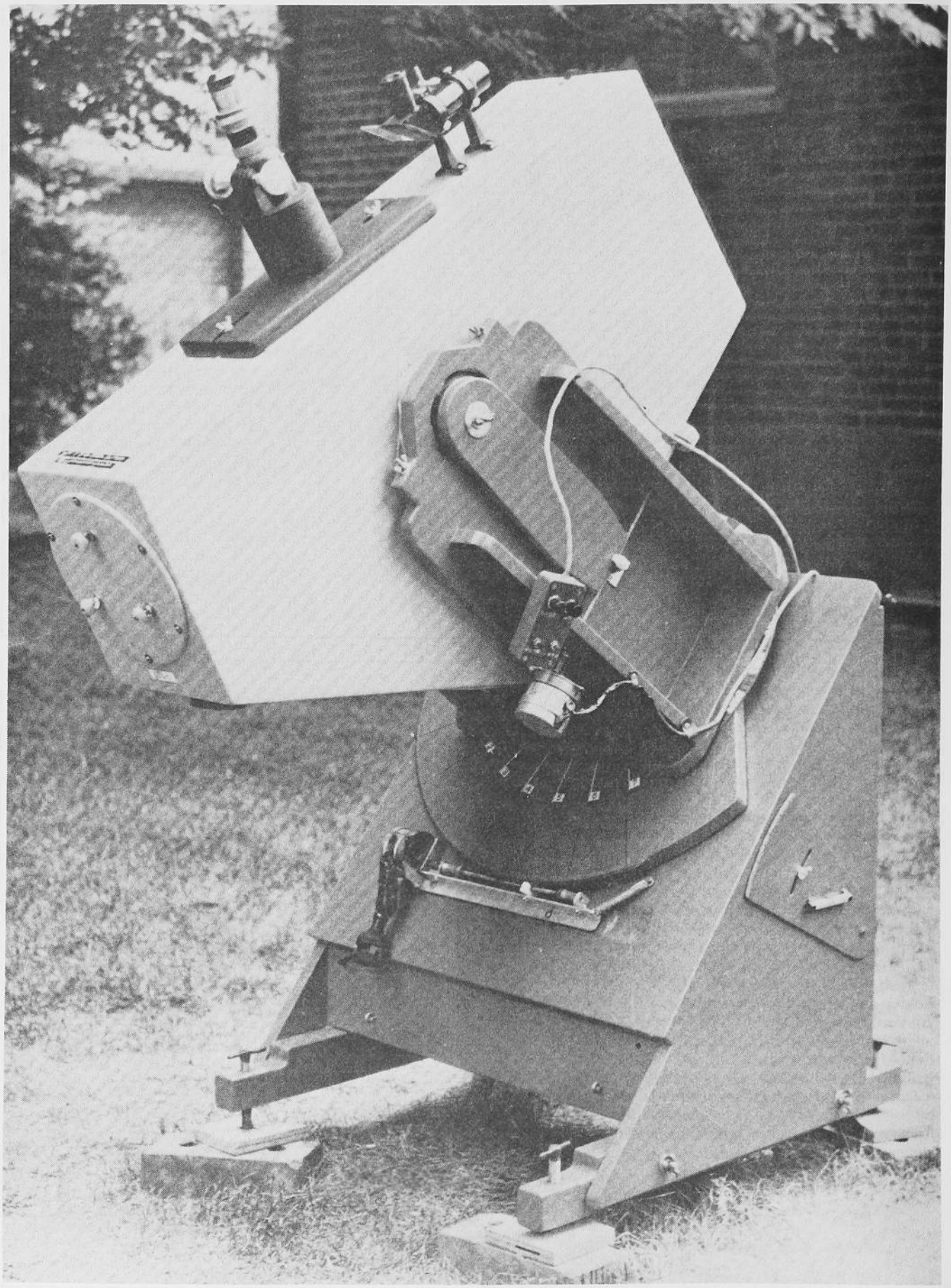
Test error with good spherical surfaces and glass qulaity is less than 1/500 wavelength peak-to-valley.

III. TRANSMISSION TEST



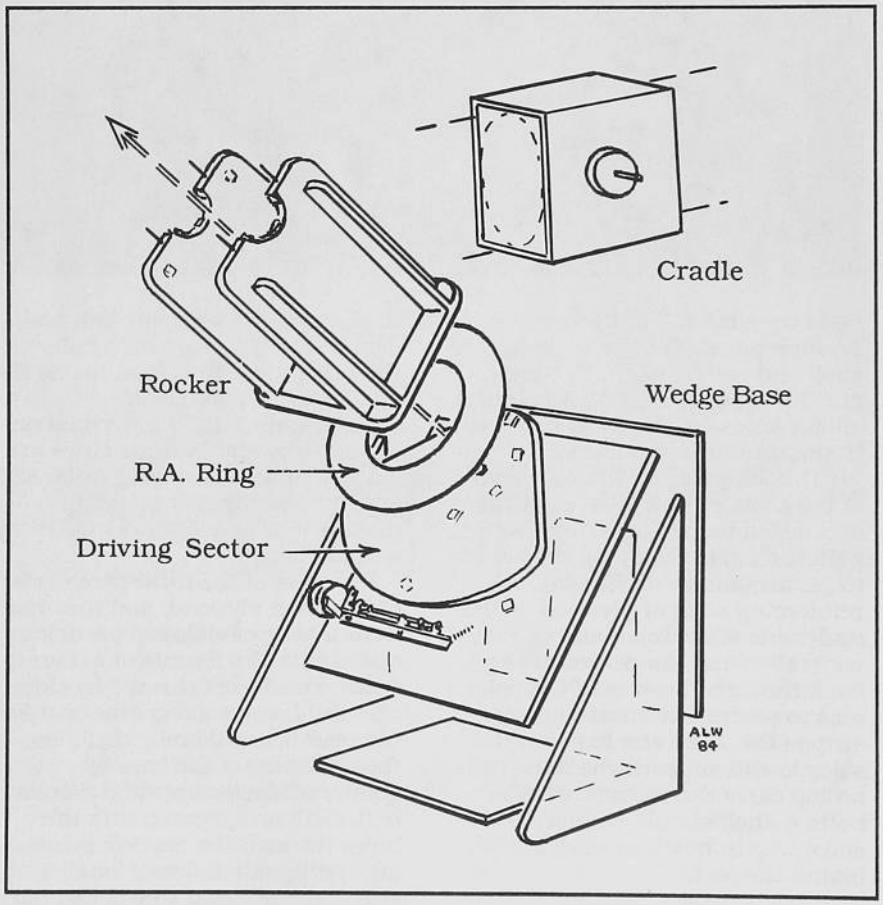
Source at center of curvature of primary mirror. All corrector lens surfaces tested in transmission.

Test error with good spherical surfaces and glass quality is less than 1/50 wavelength peak-to-valley.



An Equatorial Plate Fork Mounting

Several years ago I decided to combine the best features and design principles of Dobsonian and Poncet in an adaptation of the equatorial plate as used by Foucault *circa* 1860. Before me, Porter had picked up the design in **ATM-1**, and Wayne Wooten describes something similar in *TM#6*. Well, I built it and it worked. By floating the Dobsonian rocker box on a driving plate *a la Poncet*, tilting the base to the plane of the celestial equator, keeping the profile low, and balancing the telescope with the weight of the base, I got the best of both worlds. This description is now offered for others who will enjoy building -- and further developing -- the equatorial plate mounting.



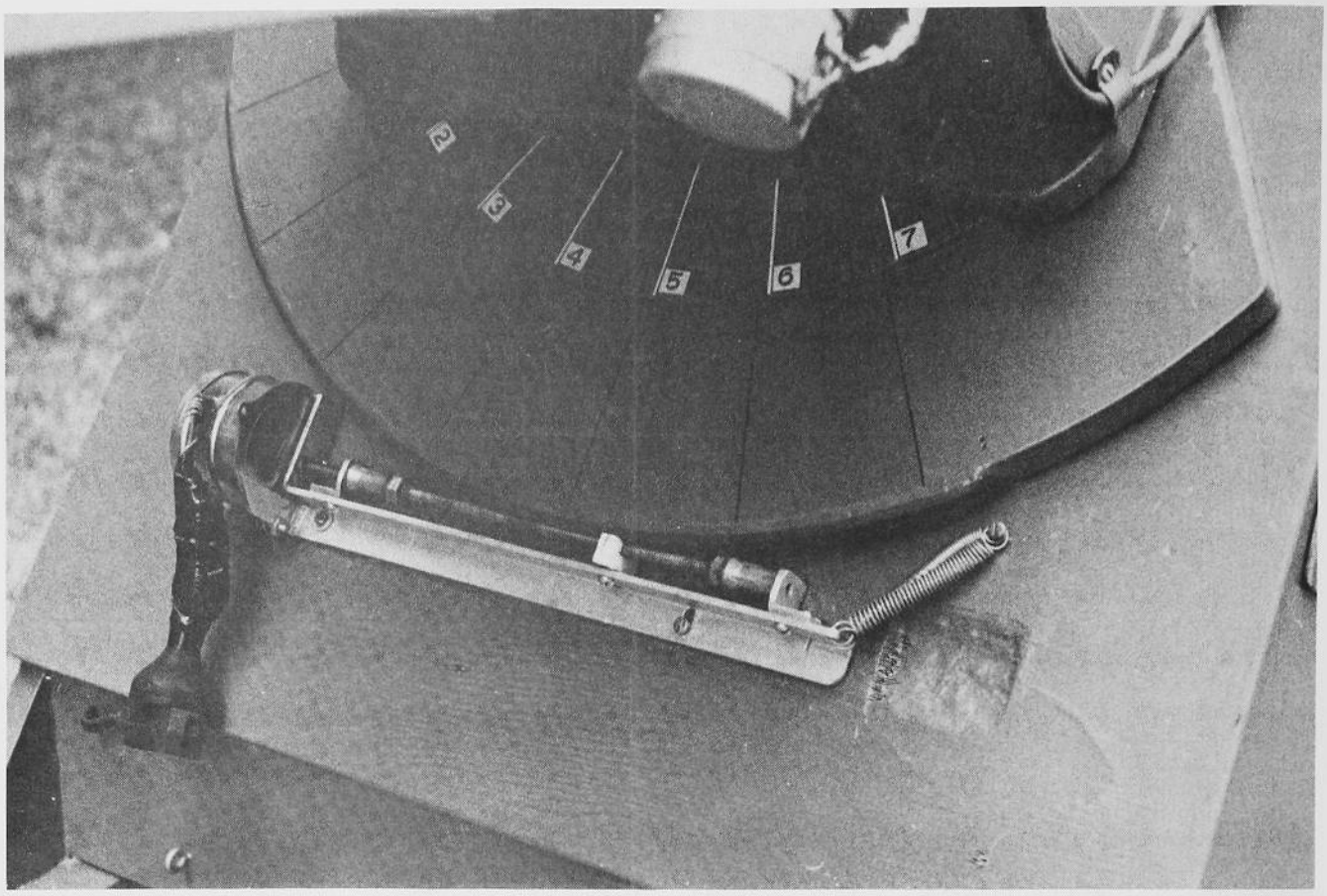
This functional equatorial mount is made of plywood, Teflon, epoxy, and other "low-tech" materials.

The Base

The base is a wedge shape with its face parallel to the equator. I used well-separated Teflon bearing pads and a short polar axle to reduce vibration. The base is in balance for all positions of the telescope. The orthogonal pattern of feet makes orientation to polar alignment easier. The materials I used are generally the standard Dobsonian materials -- wood, Teflon, standard hardware, plus E-POX-E paste for forming good drive-gear teeth on a sector.

I scaled dimensions for the base off a side elevation drawing showing my telescope and the planned rocker atop the base. When you make your drawing, be sure the eyepiece comes out at the height you want it. Also pay attention to where the feet are placed; the telescope's center of gravity must fall within them. These considerations will set the dimensions of the back and bottom panels. Other dimensions can be worked out as the parts are penciled out on the plywood panels.

The dimensions of the base are adaptable, but the top makes the angle of your latitude with the vertical back panel in order to be parallel with the equatorial plane. The right-triangle sides should be cut with edges square and true. I used 3/4" plywood. One 24-inch-square panel made the top; both



The drive sector is faced with gear teeth cast in epoxy and driven by a simple lead-screw mechanism. Spring tension holds it in place.

sides were cut out of the another 24-inch panel. For the bottom shelf and for the back, 1/2-inch panel was heavy enough A cutout allows access to the polar bolt and to the interior for storage.

The back panel and then the top of the same exact width are glued and nailed to the edges of the sides with the top overlapping the back to get maximum height. Glue a reinforcing strip of plywood to the underside of the top, passing vertically from the center of the back through the area of the polar axis to where a horizontal cross strip of the same size between the sides to add support where the pads on top carry the sector load. The bottom shelf should be placed according to how you plan to later install the feet.

The Fork

The fork is a conventional Dobsonian rocker with stiffening added to the arms (sides). Design the box to cradle your telescope so the box balances at the side trunnions of 4" diameter or larger and turns on Teflon pads. The trunnions in my telescope are short sections of PVC plumbing set flush around a plywood disk and fastened by a 1/4 x 4-inch bolt, threaded through it from inside the cradle, and secured by a countersunk nut. The declination drive sector and latitude circle are held by friction and wing nuts. Add caps to restrain any rocking motion that may be transmitted by a sector arm.

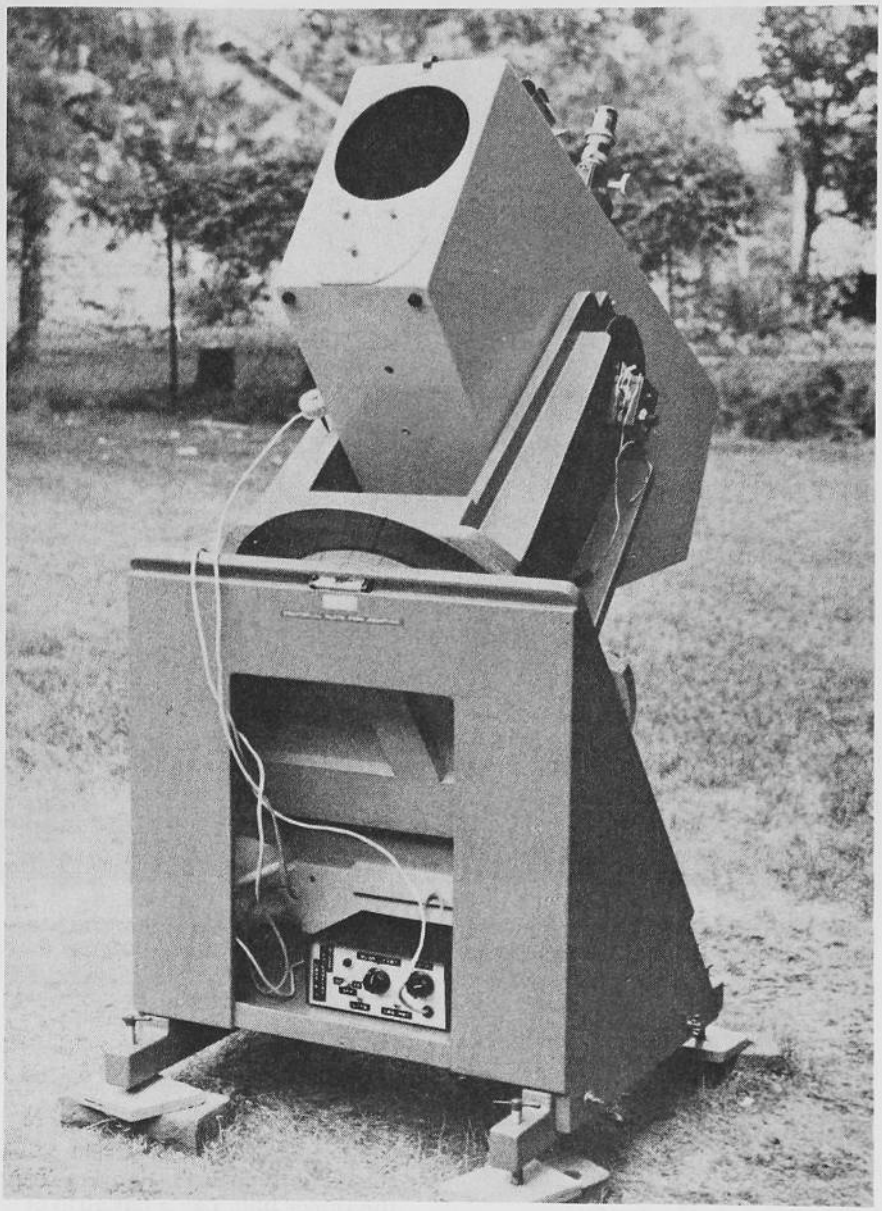
The sides of the rocker are made of 3/4-inch plywood, and they rise from a base of sink-top particle board with the Formica top face down. This base is braced by side ribs and has a solid spacer board between them, thereby doubling the thickness of the base for greater strength around the polar bolt. Drill and countersink the holes through the particle board and drill guide holes of smaller size in the plywood so you can put hefty screws in straight and solidly. A low front board between the sides helps to steady them. The sides fit the cradle snugly, and Teflon pads take the side thrust that occurs when the rocker is turned on the polar axis.

The Drive

To drive the fork equatorially, I used a large, homemade sector gear. A 3/8" machine bolt with a smooth shank holds the rocker and sector gear firmly in contact with the Teflon pads on the base. Bronze bushings 3/8" i.d. by 1/2" o.d. by 1 inch-long, obtainable in the "power tools, belting, and pulleys" section of well-equipped hardware departments, are inserted into each part to take the strain and wear off the wooden structure.

Drill the 1/2" hole as nearly perpendicular as possible through the rocker and the base with a "Speedbor" type electric drill wood bit. The bushing will fit loosely and must be set in epoxy. Spread it into the sides of the hole and on the bushing and then press the bushing into the hole in the base until it is almost flush with the surface. Insert another bushing from the bottom of the rocker flush with the surface. Remove any epoxy that gets squeezed out.

Insert a greased bolt from the



The base must support the fork solidly -- note reinforcement. The base also provides storage for the drive corrector, batteries, etc.

underside of the base through the rocker and cap with a washer and nut. Tighten it enough to draw the parts together, but leave it loose enough to allow the rocker to rotate a little and align both parts nearly perpendicular. When contact seems uniform, tighten the nut and allow the epoxy to set. If you want, you could set another bushing in the bottom of the hole in the base, but the use of epoxy and a greased bolt does very well and gives firm support for a bolt that need not turn.

For the drive sector and base board of the rocker obtain a 20.5" x 31.5" smooth Formica-faced particle board sink cutout. It may be hard to find a flat piece even in these days of heat-set resins because the other side is exposed to variations in humidity. Several days in high or low humidity may correct this. Seal this side with a primer on a day when it is flat.

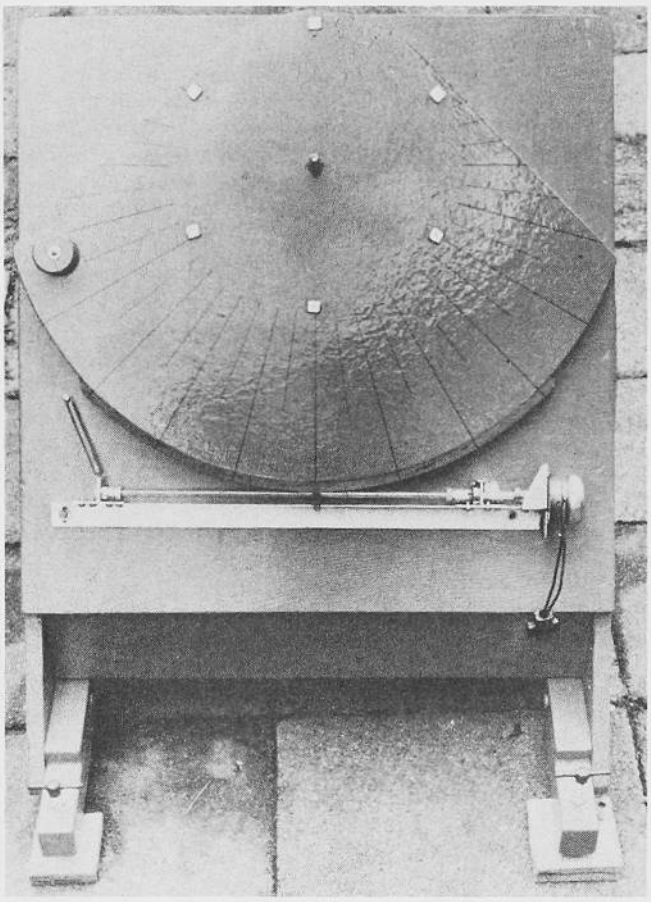
When you use a 1 rpm motor and 5/16"-18 tpi rod for the worm screw, the radius of the sidereal rate drive sector should be 12.70 inches, measured from the polar axis to the edge of the screw. (The usual formula for finding the radius of worm wheel, using E.S. King's recommended length of sidereal day in minutes, is: radius=1436.5xRPM/(2xpixTPI) This gives 12.701 inches. A radius only 0.031-inch greater gives the solar rate.

The 12" x 16" rocker base can be supported by less than the 6"-inch radius chosen around the polar axis. The pattern for the sector is drafted on the particle board side of the cutout, and the small radius is placed in the corner with the larger radius swung around from the short side to the long side. This sector gear provides up to six hours of driving time and gives the maximum width pad support for stability. Cut it out with a sabre saw and circle attachment, if one is available, with the plastic side down.

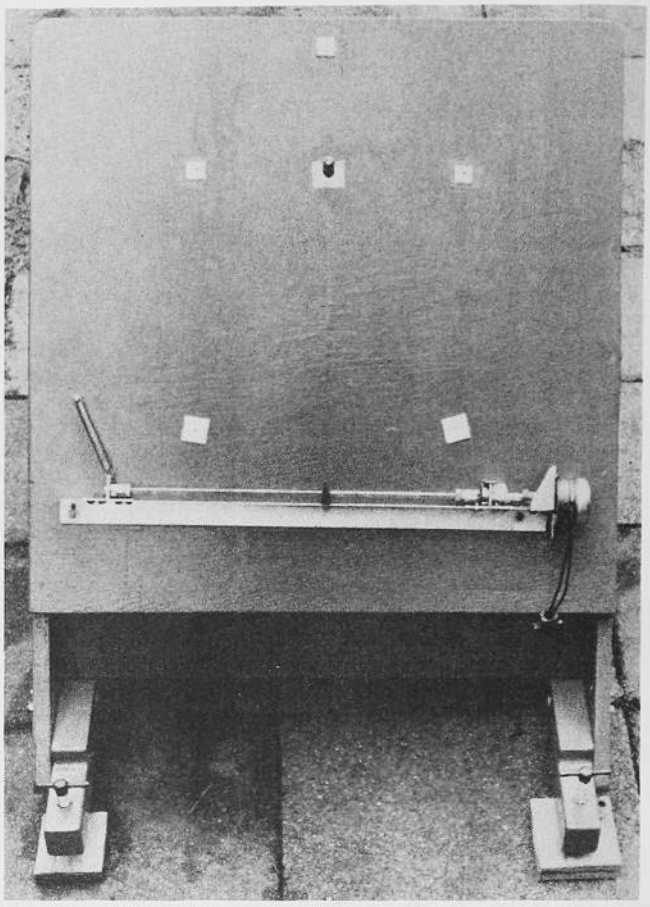
Next, drill a one-half inch hole in the center of the drive radius and a install a bushing the same way you did in base and rocker, with one end set flush with the smooth surface. Because the bushing is an inch long and the sector is 3/4-inch thick, the bushing will project from the upper surface of the sector. However, the sector will carry pieces of Teflon on the upper surface that the rocker box will turn on, so this protrusion is not a problem.

After the epoxy holding the bushing has set, make up an inspection gauge and tool from a 1x3x16-inches piece of wood. Drill a 5/16-inch hole near one end so it can pivot around a 3/8" bolt in the sector. Use this arm to hold a caliper or as a tool rest for dressing down the rim of the sector or building it up to the necessary radius with epoxy. The radius should be finished out at 12.65" because the cast epoxy gear teeth will add 0.05 inches.

The gear teeth on the sector must match standard threaded rod. Cast epoxy screw thread wears well, is easy to make, and works better than any other low-tech approach I know. I have tried a lot of ways of casting good thread on the rim of a sector. Wrapping a greased, curved threaded rod into epoxy on the sector gives a reduced pitch of thread and a slight mis-mesh that causes tracking variations acceptable only for visual use. Pressing a straight threaded rod requires you to work it into the epoxy when it has nearly set and is changing its characteristic s minute by minute, and deepening repeatedly the teeth with a pressure roll. Since you cannot control the alignment of the rod, the method often results in less-than-good track.



The equatorial plane of the base has five Teflon pads on it. All support the drive sector. Motor and lead-screw are an earlier design.



The top surface of the drive sector. Six Teflon pads provide redundant support for the base of the fork. Note knob for resetting sector.

Flat-Casting Gear Teeth

The best method is more sure and just as simple. Cast the thread on a flat surface with a straight threaded rod and then cement it onto the rim of the sector.

Tape a 2" x 26" strip of heavy-gauge (.010) polyethylene plastic by its ends to a smooth 12"x36" panel of 1/8"-tempered Masonite. Draw a straight guide line on it with a marking crayon. Apply a continuous pencil-size bead of two-part paste epoxy made from a single mix in a straight line. (I have had good results with E-POX-E brand epoxy.) Although there are sure to be some breaks in the bead, overlaps can be kneaded together and the mix kept uniform. Allow it to set for 30 minutes, until it becomes less sticky, and then lightly pat it down to a straight bead a bit less than half an inch wide. Do not heat the mix.

As its viscosity increases, flatten the bead to about 1/8" by gently patting and smoothing with wet fingers or a small pallet knife. Next press a thoroughly greased 5/16" threaded rod ("all-thread") at least 30" long straight into the epoxy strip. Be sure to keep it straight, press gently, and do not let it roll.

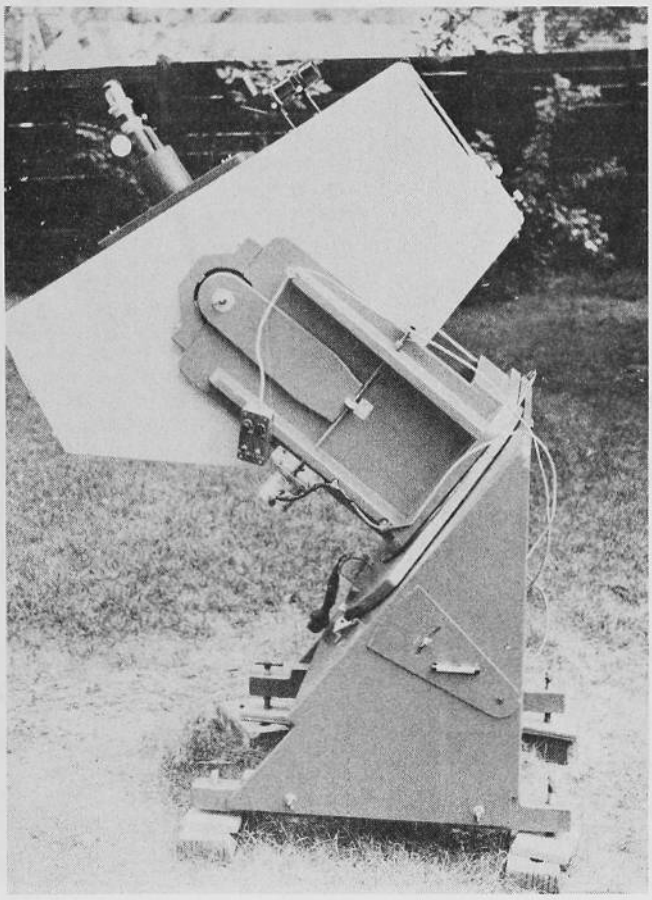
Using fingers moistened with water, work the epoxy strip against the rod, but do not get any epoxy on the upper half. Lay a flat strip of wood on the rod and weight it so the rod is pressed down to the plastic. Let the epoxy set for a while.

Remove the wood and pinch the expanded epoxy gently back to the rod again. Then smooth down both sides so they are about 1/8" thick with a pallet knife or the flat of a small knife blade. Trim off material from the sides if the the total width of the strip exceeds 5/8". Although the grease on the rod will keep the epoxy from sticking, do not fold any of the epoxy back on itself or into the threads above the flatted strip.

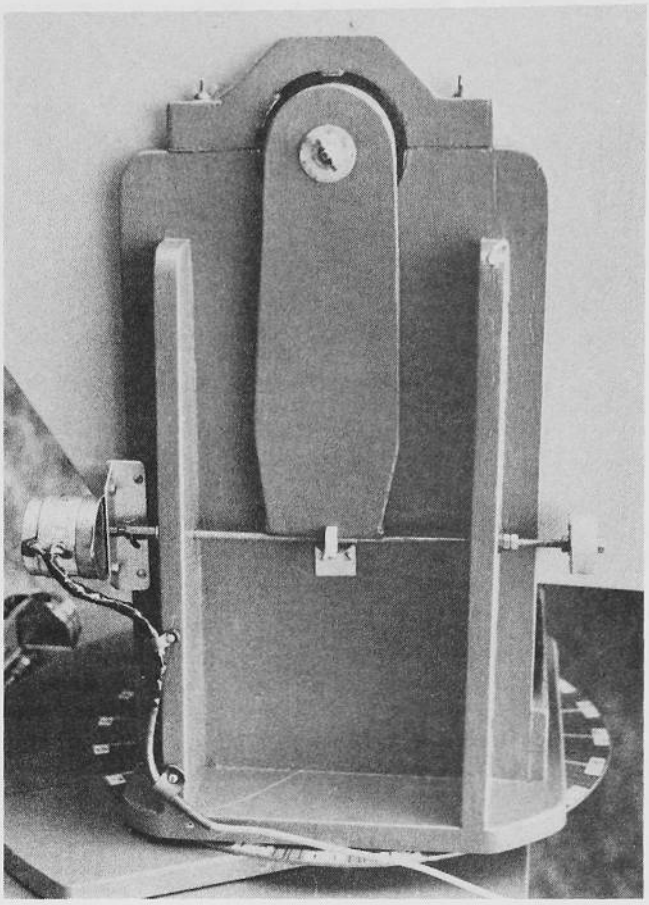
When the epoxy becomes a bit firmer but still yields to a slight dent by a fingernail, lift each end of the rod slightly. While holding down the casting on both sides of the rod, lift the rod just enough to open a very slight separation. You can judge from the action of the grease that the rod has separated. Work from the ends to the middle. Do not overdo or hurry the work, or the cast may crack under the rod where it is thin.

Allow the epoxy to set until it resists a nail imprint, and then lift the rod from one end while holding down both sides of the casting with two 1-inch boards on edge. Vibrate the rod gently as it is pulled up between the boards working towards the middle. Keep the casting on the plastic strip and panel for sanding down to a uniform thickness after it has cured overnight. Use 40-grit production paper for this and for finishing the piece to a width a little less than the width of the sector rim.

Excess epoxy may be rolled into a ball as a test to judge the condition and speed of setting. If you have not used this kind of material before,



Side view of the mounting. Note level for setting telescope to different latitudes and slow-motion tangent arm in declination.



Close-up of the declination tangent arm. Note "low-tech" Teflon bearing, wing-nut clamp for tangent arm, cast-epoxy teeth on arm.

make a small ball to observe its setting action.

Attaching the Cast Threads

Saw the casting to required length with a hacksaw and mark the position the casting will take on the rim of the sector. Spread a very thin coating on the flat side of the casting and the sector rim. Stand the sector on edge and press one end of the casting in place, press it very firmly into contact with the rim and strap it down with strong masking tape. Proceed along the sector, firmly pressing the next few inches down, squeezing out as much epoxy as you can, then taping the casting securely to the sector as you go. You can let the free end of the casting hang and sag under its own weight but keep heavy pressure on where it contacts the rim. You will need to tape the first few inches heavily to keep the strip from slipping.

As you proceed, make sure the axis of the screw track remains parallel to the edge of the sector and that there are no ripples in it. Next day clear off the tape and dress the casting with file or fine rasp. This casting technique can be used with larger rods and for other systems of drives.

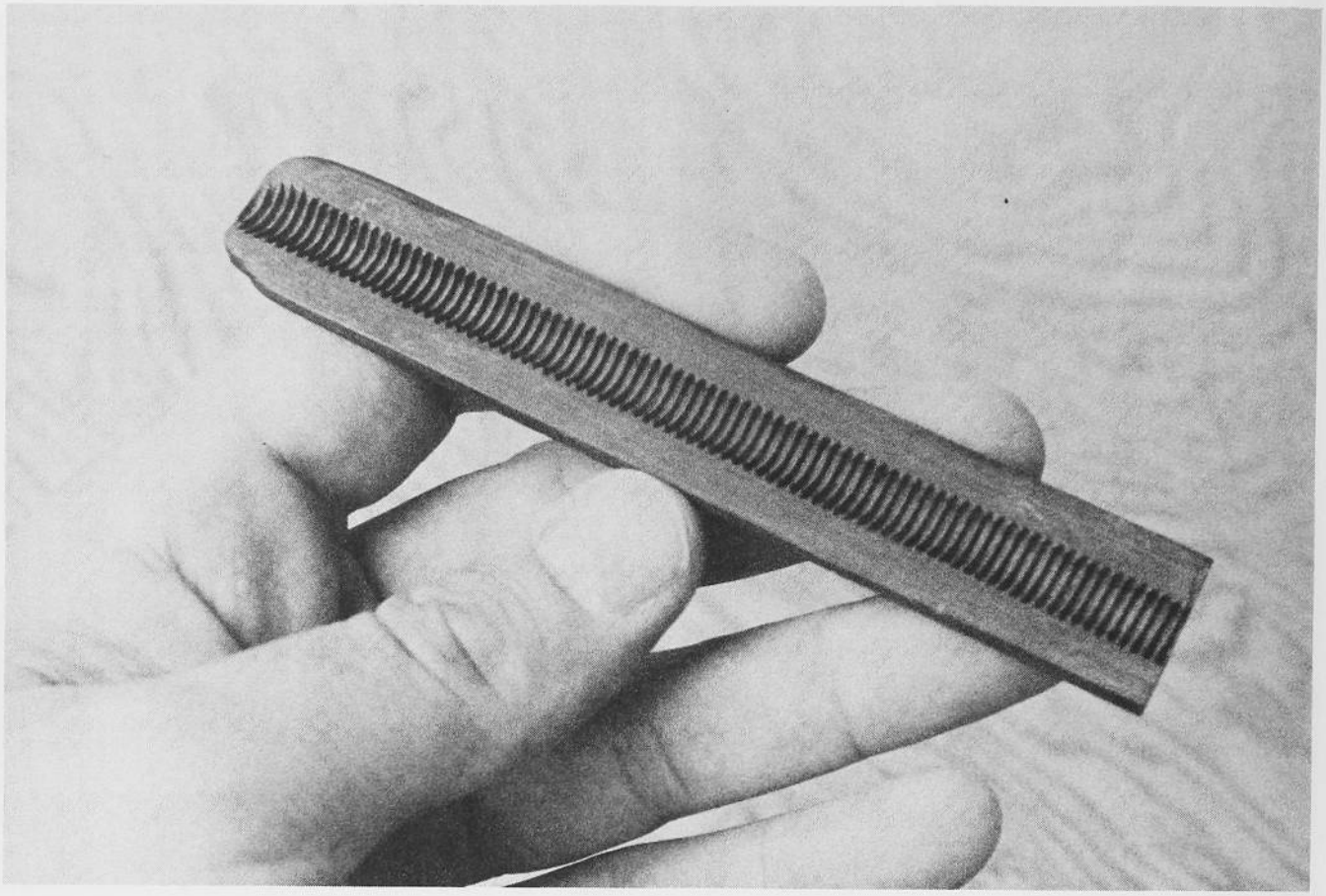
The Motor Drive Unit

The worm drive is built on a frame of 3/4" x3 /4" x 1/8" aluminum angle extrusion split at one end and bent to hold a 1-rpm synchronous motor. I used a 5-watt reversible motor -- reversible to obtain the nonstandard counterclockwise rotation -- so a single steel ball bearing can take the thrust.

Brackets made of the angle support the ends of the 5/16" threaded rod by using the internally threaded die cast insert of a Tampin masonry bolt anchor. I epoxied a short length of 1/4" copper tubing with a bit of shim brass into the large end of one Tampin to turn in a hole of an aluminum bracket and fit the motor shaft. A 5/16" steel ball is epoxied in the small end of another Tampin; it turns in a conical hole in the other bracket. The piece of rod and the Tampin fittings are locked with hex nuts after you have adjusted the end thrust and then sealed them in place with some clear epoxy. A Teflon block steadies the worm screw against the sector. This is one-half of a block that had a 5/16" hole drilled in it first, cut, and bolted onto the frame midway.

The frame pivots on a screw near the motor, and the worm is pressed against the sector by a spring on the opposite end. This keeps the contact steady. It is also easy to manually disengage the worm to reset the sector back to its beginning. Adjust the worm to perfect fit against the screw track by shimming between the frame and the base

Before I installed the present motor, I used a standard 3-watt 1-rpm clockwise motor driving from the right side. It was able to handle my telescope's weight, but a periodic error originating in the thrust end of the rod, occasioned by



A short section of cast epoxy worm gear track. The finished track is about 1/8" thick by 3/4" wide, and is quite stiff.

the unmachined parts I used, frustrated my attempts at prime focus photography. Even a small ball bearing could not eliminate the problem. This drive was adequate for visual observing.

I added the setting circle recently. It is made of 1/8" mahogany plywood. The o.d. is large enough for the markings to show up outside the rocker, and the i.d small enough that the whole ring can rotate on the circle of Teflon pads supporting the rocker. The circumference of the ring is divided into hours and subdivisions. To make the ring, I painted it. After paint surface dried, I scoured it lightly with Ajax powder, marked it with black india ink in a ruling pen, and then sealed the surface with an aerosol spray of clear gloss urethane enamel.

Bearings

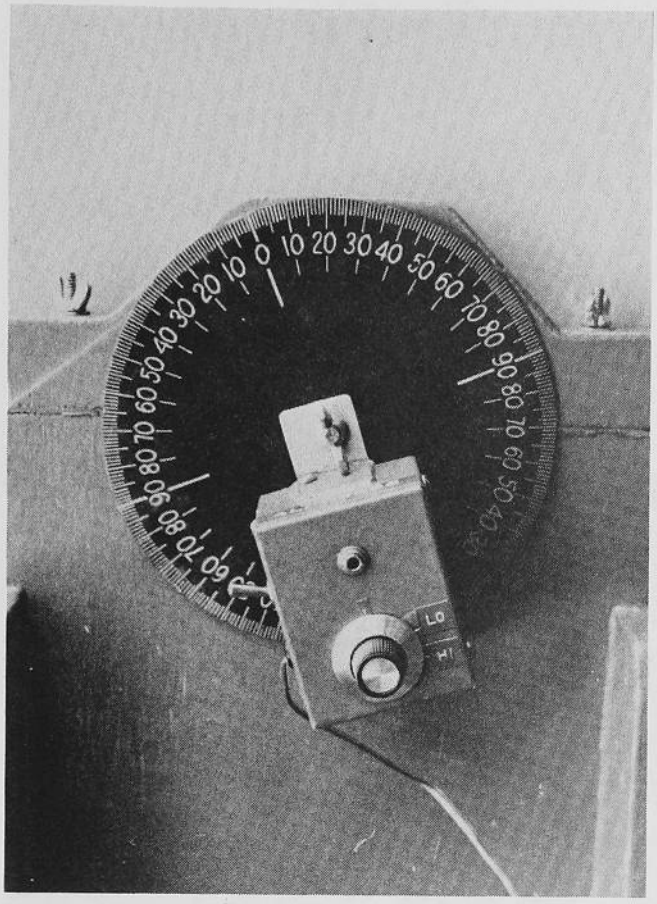
The bearings are Teflon pads nailed in place. I put them on after painting was completed. A small drill bit twirled between your fingers will make a small conical depression to guide the nail and sink the head. Teflon is available in 1/16- to 1/4-inch thickness; the thin stock is cut with a sharp knife or heavy shears, but the thick pads take a fine-toothed saw.

Ideally only the three pads should be required to support the driving sector on the equatorial face of the base, one as a washer with a 3/8" hole at the polar axis and the other two near the arc of the sector screw track about 30 degrees on each side of meridian. To limit play in the polar axis under the load of the rotating rocker, it is practical to set a small pad 5 inches on each side and above the polar bearing. I prefer the 1/16"-thick Teflon for this because it is easier to establish the necessary mating of worm and sector screw track with the thin material.

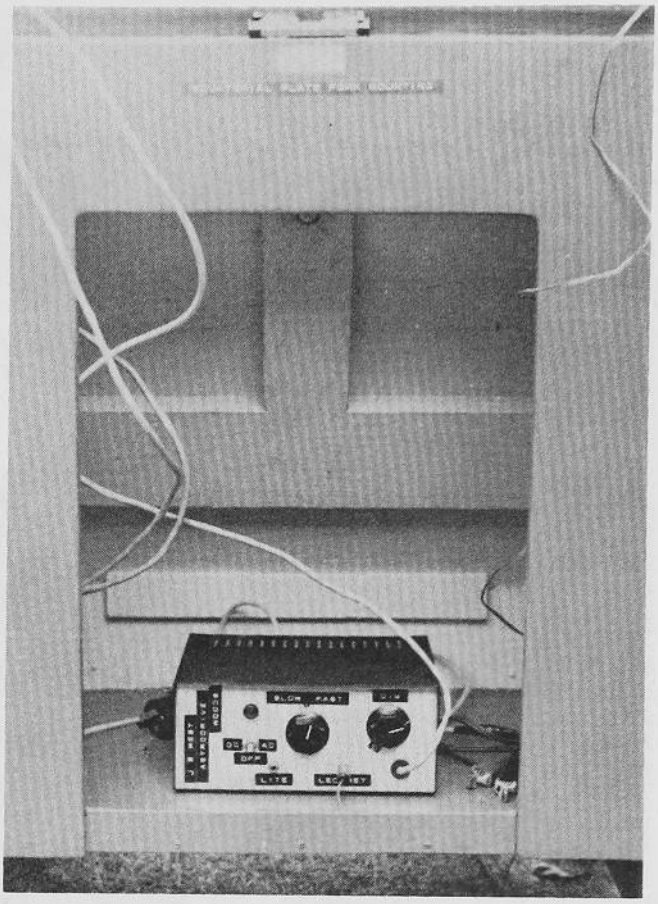
Since the sector will be in many positions, place six small pads on it to support the rocker. These should be spread radially about the bearing so the outside edges are in a true circle around which the R.A. ring may turn smoothly. These must be 1/4" or more thick to hold the rocker off the ring.

Because I found that the bolt pressure necessary to hold all parts securely on the pads for very close tracking in astrophotography resulted in too much friction, I experimented with a ball bearing "lazy Susan" between the sector and rocker. This ball race required a full 1/4" of clearance, so I adjusted the height of the pads until their contact was just enough to stabilize the rocker and prevent the rocker from spinning freely. I also sank small roller bearings into the top next to the pads supporting the lower part of the sector to take the load off the pads. Here I compromised the pure Dobsonian principle, which would have been unneeded for a visual use only telescope. The ball bearings may be necessary for all heavier telescopes.

The polar bolt you use in final assembly will be nearly 4.5" long, but it needs only the bottom 3/4-inch threaded. The rest of the shank should be smooth so it will turn in the bushings properly. The bolt does not turn against the base bushing, which is intended only



Declination circle mounted on trunion. Note wingnuts: these hold trunions in place. Box houses power supply for guiding reticle.



Detail of the back of the base. Bubble level permits quick, accurate setups. Reinforced equatorial plane is essential to a solid mount.

for a solid footing in the wood. Sandwich a Teflon washer between metal washers under the retaining nut holding the rocker. To keep the smooth underfacing of the rocker squarely on the pads of the sector, tension the bolt to allow the rocker to turn smoothly. Make a retaining nut by combining a half-thickness nut soldered to a thin metal lug bent up. Coat its end with plastic to provide convenient no-tool finger tightening, and lock it with a wing nut. Keep the bolt well greased.

Leveling

Screw jacks at the corners of the base provide fine polar alignment, as well as compensate for unlevel ground. The jacks are four-inch lengths of 1/2" threaded rod through hex nuts set and epoxied into the underside of 2 x 3 supports. These supports can be demounted from the base.

The lower ends of the jacks are rounded to fit into sockets in small plywood ground pads. One jack is ground to a cone and is a pivot point to rest in a ground pad for orienting the base in the horizontal plane. The upper ends of the jacks are drilled to take a small rod or ten-penny nail and then repeatedly dipped in a plastisol used to coat tool handles for an insulated hand grip.

I use small pocket bubble levels to orient the polar axis. One is horizontal at the top of the base back panel and one is on a small sector at the side of the base and centered perpendicular to the equatorial plane for setting the polar altitude. When the base has finally been set on a satisfactory alignment, cement the level into this sector with the bubble centered, and calibrate the rim in degrees. When you move the mount to another location, the base can be leveled in daylight. After dark you can rotate the other jack to get a good alignment. At a different latitude needs you only need to set the bubble sector to guide the initial setup.

The orthogonal pattern of the feet gives a controlled method of shifting to perfect the alignment by correcting the north-south drift of a meridional star positioned in the eyepiece.

Transport

For transport, the telescope, its cradle, rocker, and base are stowed separately. The rocker and base total about 50 pounds. While not as portable as the suitcase variety, this mounting has been easy to take apart and set up. I have taken my Shiefspiegler to various meetings in a Chevette. I normally keep the mounting outdoors; it is tough enough to have come through a couple of years outdoors under a plastic bag without change or deterioration.

I am sure you will enjoy using a continuous RA drive on a mounting that moves with Dobsonian smoothness -- and when you select an object to view, it stays with you until you choose to move.

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■

A Simple Practical Light Source for the Foucault Test

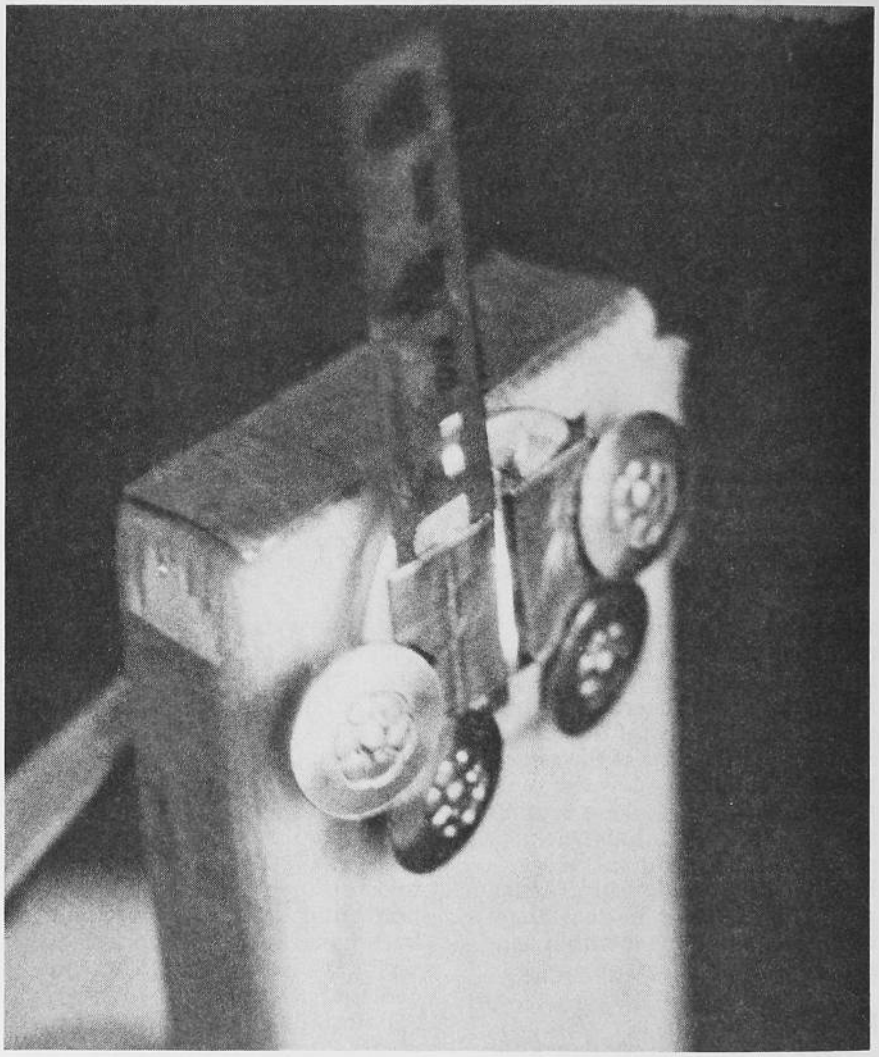
I have found a simple way to make a light source for a Foucault tester. I came upon the idea while I was building a slitless tester inspired by the design Dick Suiter described in his article "On Slitless Testers" (*TM#22*, pg 16). My design avoids the use of prisms or other reflecting surfaces, and, aside from its simplicity, it is nice because it is extremely compact.

The heart of the device is a bulb manufactured by Maglite for use in its Mini-Maglite series of flashlights. Replacement bulbs are sold two to the pack at most outdoor sporting stores. The bulb comes with two short, stiff wire leads that facilitate clipping power leads via alligator clips.

These bulbs are extremely bright. One would serve as an excellent artificial star for star testing during the day or on cloudy nights. They are also quite tiny with a diameter of only 1/8". Two AA batteries make a suitable power source and will last a long time. I've used the same bulb and batteries for figuring two mirrors.

The bulb is mounted in a piece of wood about 1/2-inch thick, and of whatever height and width fits your tester base. Drill a hole completely through the wood 1/2" from the end of the wood that will become the top of the tester. To diffuse the light, place five or six layers of Scotch Magic tape over the hole.

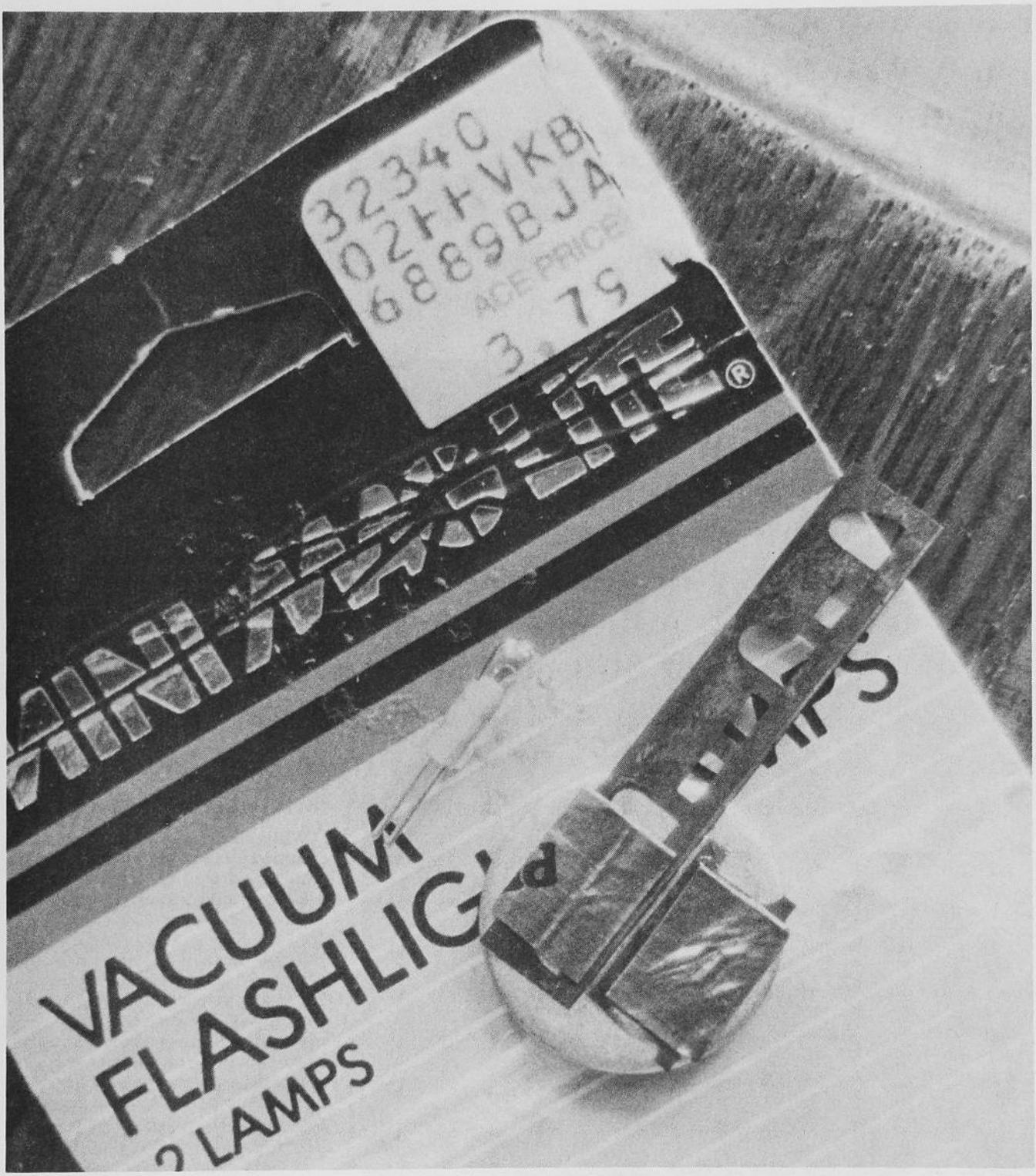
Cut a piece of opaque film cannister to 1/2 by 3/4 inches. Use a straight pin to pierce two holes in the plastic and then slide the leads of the bulb through. Stick the bulb snugly into the drilled hole. (The top of the bulb will point at the mirror.) The plastic keeps light from shining in your eyes and anchors the bulb in the wood. Attach the plastic-and-bulb subassembly to the wood with tape, tacks or screws. Spread the wire leads away from one another to facilitate attaching alligator clips to them or solder longer wires to them.



A tiny lamp made for a miniature flashlight illuminates the slit.

I have found that Radio Shack is a good place for parts. These stores sell a two AA battery holder for under a dollar, and also carry micro-alligator clips and knobs with 50 graduations.per turn. These are indispensible for fabricating the "micrometer" screw adjustment in a slitless tester similar to the testers pictured in *TM #22*.

My tester is not a "slitless" tester. The knife edge is a stainless blade



The lamp is held in a thin piece of wood; the slit supported by tacks.

from a Gillette Good News Razor. The simplest way to extract it from the plastic head is to set fire to it and burn it out. Using five minute epoxy, I secure the blade across the hole of a 1/4" metal washer. Rather than use a mask as discussed in *TM* #22, I break off a piece of the remaining blade to a size sufficient to epoxy the blade to the washer to form a slit between the knife edge and the smaller piece. The washer assembly sits against the scotch tape in front of the hole, secured with tacks.

You'll find it handy to make several slit assemblies with various slit widths. Primary ripple can be detected with a narrow slit, and the Maglite bulb generates enough light to go through an extremely small slit. The assembly can be popped in and out to for alignment or the use of Ronchi screens.

Gil Stacy
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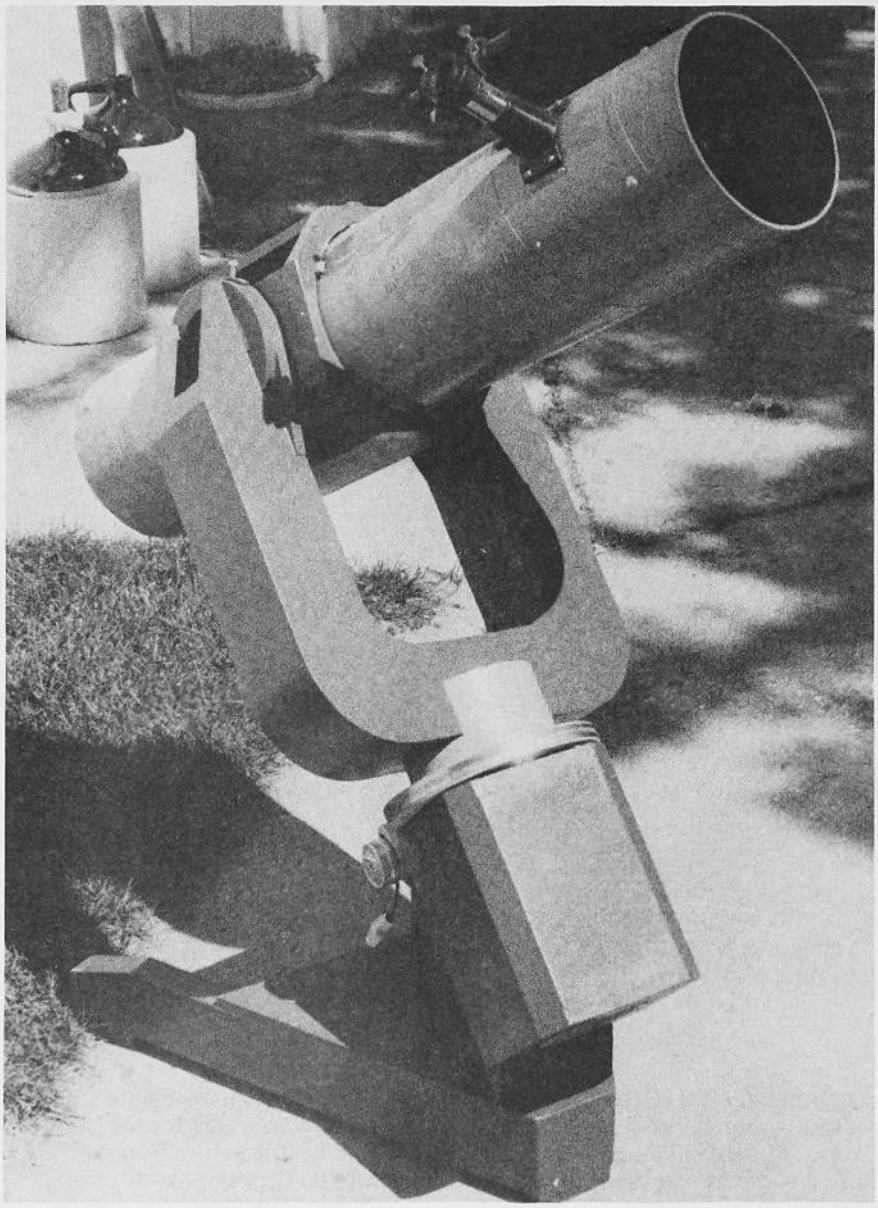
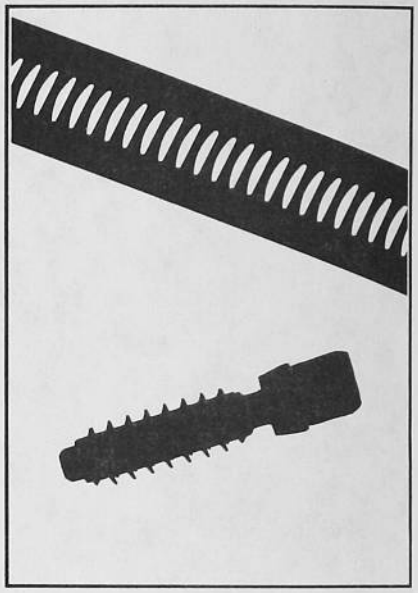
The Hose-Clamp Drive

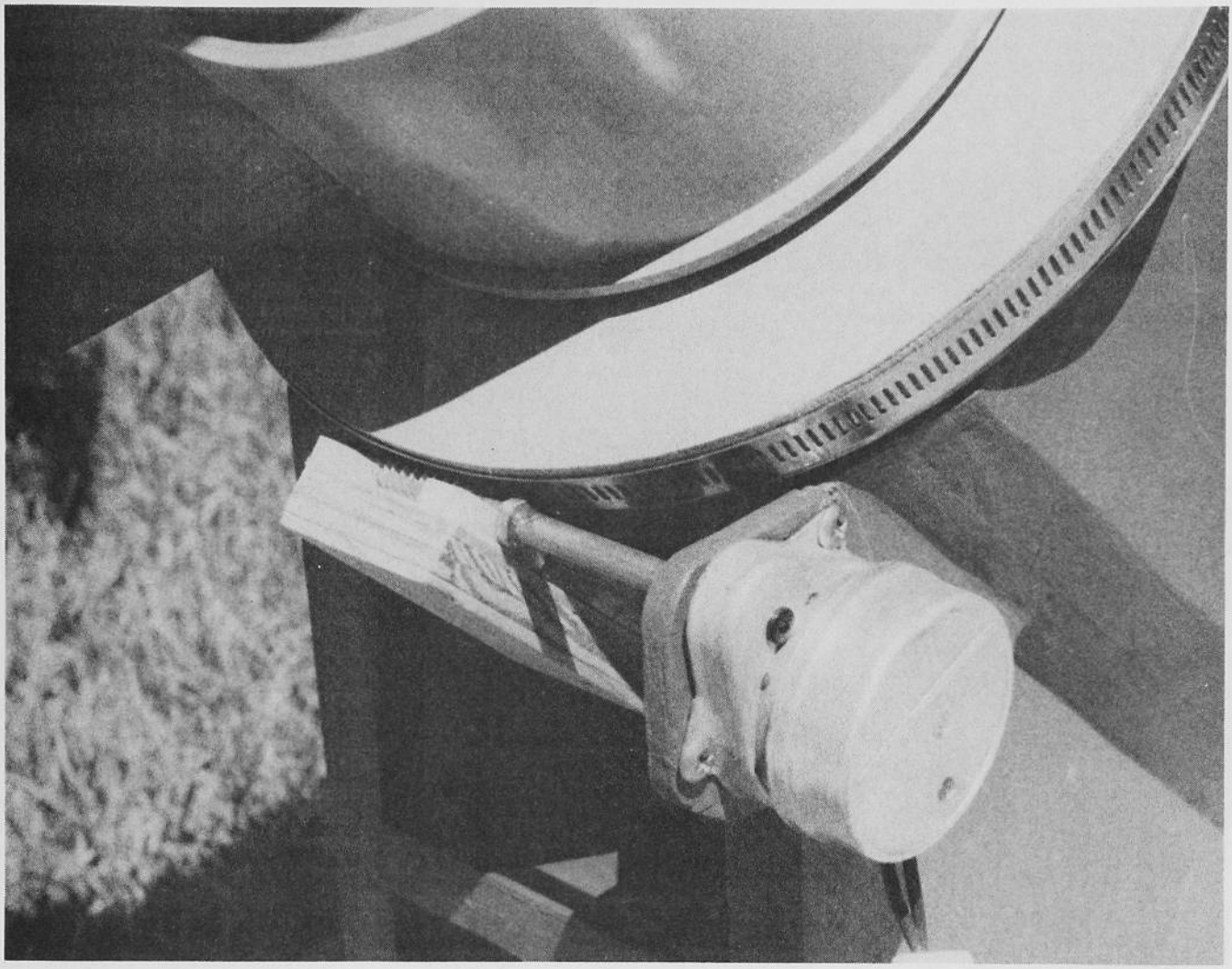




While designing a 6-inch fork-mounted Newtonian, I had trouble finding a drive that was both effective and inexpensive. In talking with other ATMs I found that the drive is one of the most difficult parts of a telescope to make and very expensive to buy. I hope this article will help others like myself, because the hose-clamp drive I have developed is both effective and inexpensive.

The drive gear consists of a long hose clamp band wrapped around a plywood disk. A hose-clamp worm drives the disk. A member of the

Jeff Inman's 6" f/6 Newtonian reflector is mounted on an exceptionally solid fork mount with a hose-clamp drive on the RA axis. Construction is mainly from plywood, 2x4s, and PVC pipe.



The drive consists of a hose-clamp gear and a worm driven by a 0.2-rpm synchronous motor. The pressure plate with Teflon wear pad eliminates the need for a more complex worm support.

LCAS, Richard Burns, uses a plywood disk similar to mine on his German equatorial. Brian Grovendover, another member of the LCAS club, has long used an arrangement with a pulley wheel rather than a plywood disk to carry the hose clamp band. All three of us have found hose clamps to be smooth and effective drives.

I know of only two kinds of hose clamps. One has elliptical-cut angled grooves and the other has parallel-cut grooves. The elliptical-cut bands fit their worms too loosely, which makes them nearly useless for driving a telescope.

However, a parallel-cut clamp band, when combined with a worm from a elliptical hose clamp, makes a snug fit with no play whatsoever. These make good drives.

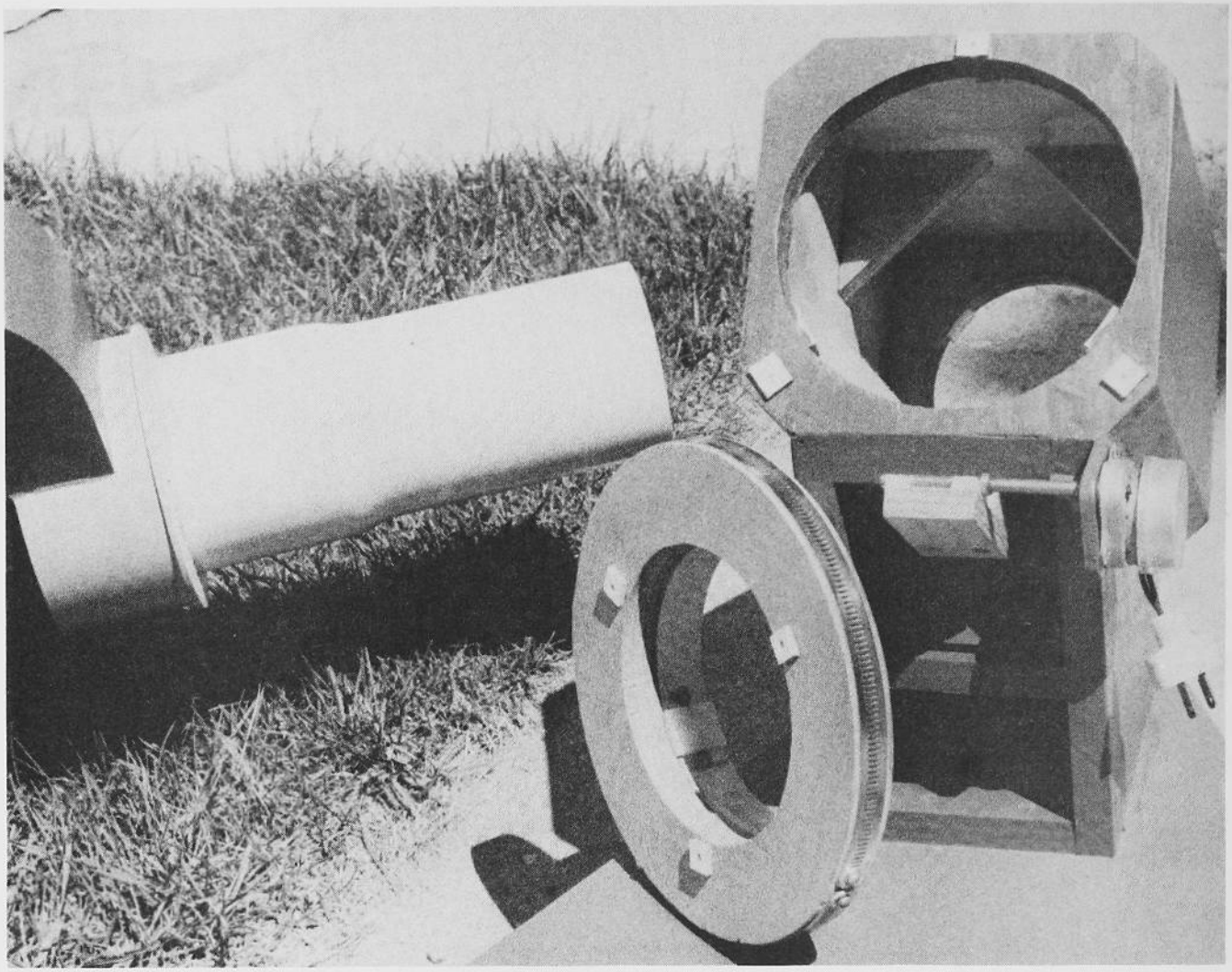
I use "Hi-Torque" worms from Breeze Corp. These are case-hardened, and are over 3/4" long. I couple this worm with a stainless steel "Snaplock" band with parallel-cut grooves made by the Ideal Corp. of Brooklyn, NY. The band on this clamp is over 33 inches long.

The clamp and worm have ten teeth per inch. The motor runs at one-fifth RPM. Using the Poncet gear-wheel formula (*TM#8*, page 23) I came up with a wheel 9.14 inches in diameter. I cut the disk with a jig saw with a compass arm attachment.

I coupled the worm to the motor with a piece of quarter-inch steel brake line tubing available at auto parts stores. The tube fits over the shaft on either side of the worm. Cut the screw head from the worm. I used epoxy to attach mine; this works as long as you score or nick the shaft so that glue has a better binding surface.

The tube and the worm could also be brazed or silver-soldered together. Center the worm in a lathe and bore a hole in the ends. Insert the shaft ends and glue, braze, or silver solder them in place. This is the way Richard Burns did it on his drive.

I have noticed that the teeth of



The disassembled polar axis part of the mounting. Teflon pads define the position and rotation of the 4"-diameter PVC plastic polar axis. Gravity holds the assembly together.

some worms are tapered on one side and flat on the other side. The flat side is better for driving purposes. It is also a good idea to file a groove around the plywood disk for clearance of the teeth. A round file does the job in a few minutes.

On my drive the worm is held against the wheel by Teflon bearing blocks that bear on the main shaft and the stub of shaft on the other side of the worm. The Teflon bearing blocks are mounted on a piece of plywood that applies tension between the worm and drive disk, giving it a tight backlash-free fit.

I used a similar arrangement on a Poncet mount. In this mount the Teflon bearings were mounted on a spring loaded steel plate that runs in a channel on the base plate. This allows it to be pulled down after a bolt is removed from the motor mount plate, thereby dissengaging the worm from the clamp and allowing the drive to be reset. In this case only a short section of clamp band was needed, enough to track for about an hour.

So far this type of drive has worked on two German equatorials, a fork mount, a Poncet mount. This leads me to believe that it could be adapted to virtually any type of mount.

On my fork mount, I placed the drive disk between the base of the fork and the polar shaft housing, with Teflon bearings throughout. The polar shaft is made of 4" PVC pipe fitted to a 4" to 6" adaptor that forms the base of the fork. The drive disk has a 1" long by 6" diameter piece of PVC tubing, as can be seen in one of the photos, supported on Teflon bearings within that support the 4" PVC shaft.

The PVC pipe on the drive disk rides on Teflon pads inside the polar shaft housing. The southern end of the shaft rides on Teflon on the top of the southern end of the polar shaft housing box. The back of the drive disk is covered with Formica and rides on Teflon pads mounted on the face of the polar housing. The Teflon pads on the

face of the drive disk support the PVC flange at the base of the fork.

The fork is a hollow structure of 1/2" plywood, making it lightweight but still very sturdy. The motions in R.A. are very smooth. I used PVC and Teflon bearings in the Declination axis, and they are also quite smooth. So far the drive has worked fine for visual work, and even some unguided piggyback photography.

The drive can be made more accurate by cutting the disk on a lathe, like the one Richard Burns made. Lapping the worm with the clamp band with extra fine abrasives would probably make it even smoother. Hose clamps seem to be fairly accurately made, and therefore can be made to work quite well.

Richard Burns' 8" f/5.6 Newtonian reflector features a German equatorial mount with a hose-clamp drive gear. Overall view shows the location of the gear in the mounting. Closeup photo (above) shows the worm on a long shaft supported by a spring-laoded eye-bolt at left and the motor at the right end. The worm was drilled out, then shafts were inserted and brazed . Note the parallel-cut style of the clamp band. The drive gear is made of 3/4-inch plywood.

I would like to further test his drive and improve on it, eventually using it for prime focus photography. I hope to drive my new 13.1-inch with a hose-clamp drive, and eventually do prime focus photography with it, too.

Jeff Inman
38455 N. Sheridan Rd. #770
Waukegan, IL 60087

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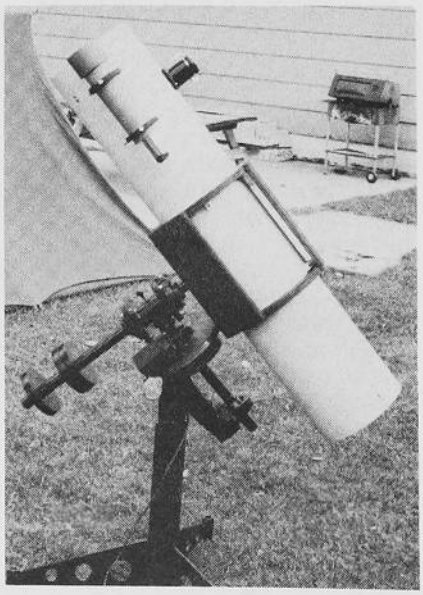
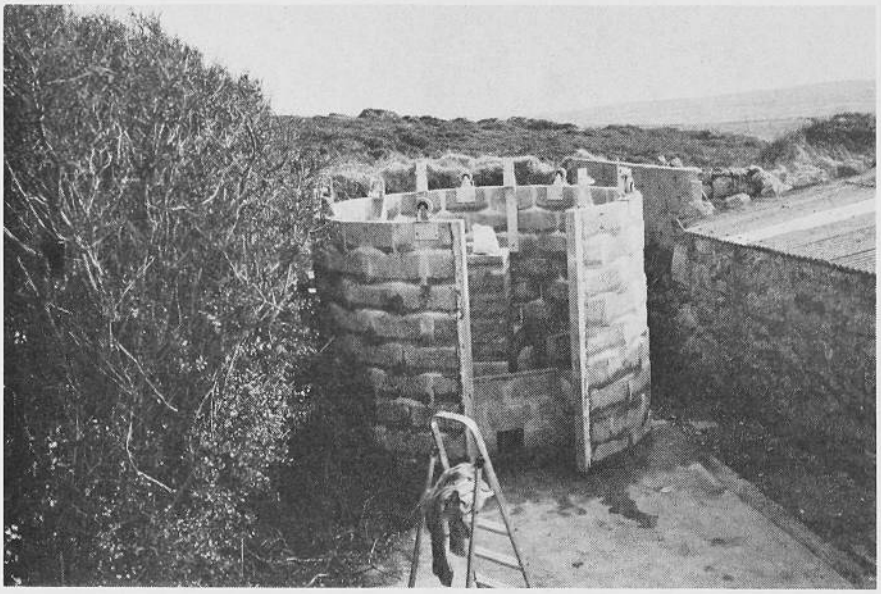


Watchcroft Observatory

The Most Westerly Dome in England



The block building with dome roller mechanisms installed.

Having bought a remote house with panoramic views and no street lights or neighbours, I had decided to build some sort of permanent housing where my telescope could be left set up. After considering sheds with run-off roofs and other more outlandish schemes, I realized that what I *really* wanted was a 'proper' dome.

I looked through magazines and books to determine what sort of dome I wanted. It had to be pleasing to look at. It had to be functional. It had to be something I could build myself. And, above all else, it had to be weatherproof.

Its size was determined by an old concrete plinth between my garage and a wall, which meant an outside diameter for the base of nine feet. I decided on concrete block walls and (at that time) to build the dome in either plywood or aluminium.

On Christmas holiday, with no previous experience, I took the bull by the horns and ordered the concrete blocks, sand, and cement, bought a couple of buckets and a shovel, and got stuck in!

I chalked out a 9-foot circle and started to build the blocks around it. After the second course I realized it was becoming difficult to keep the circle true. I concluded that a post kept perfectly vertical in the center with a piece of string and a knot in it at the outside diameter of the circle would keep things centered. This simple but vital innovation worked very well.

Mixing the cement by hand and working weekends only, it was quite a few months before the walls, pier, and supports for the raised floor were completed. During that time I had to contend with violent icy winds, heavy rain, hail, and thick snow in this very exposed location but it taught me that whatever else my dome would have to be strong -- and weatherproof.

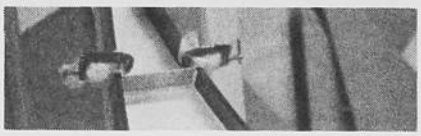
With the walls completed I turned my attention to the problem of constructing of the dome. I was working one step at a time and had not given detailed thought to how I would actually construct it, although I had plenty of ideas. I looked seriously into steaming wooden ribs and then gluing and clamping thin plywood and covering it with a layer of fibreglass. At about that time I saw an article (in *S&T*, June 1985) by Japanese amateur Tatsuro Matsumoto. He had built a dome using fibreglass. I resolved to construct my dome with this material, although what I planned would structurally and technically be quite different from the one in the article.

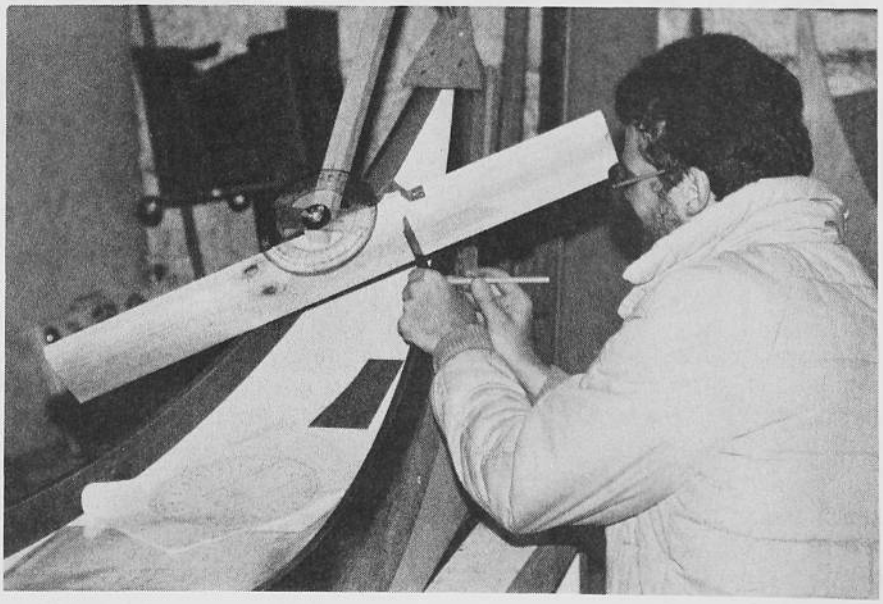
I constructed the base ring out of two layers of 3/4-inch marine plywood 6 inches wide, to run on inverted trolley wheels. Each layer of the ring came nicely out of one sheet of 8'x4' marine ply. After much mental effort, I finally designed the mould that I would use for the segments! I had used two layers of 10'x5' 3/4-inch blockboard as a base for scribing, cutting, gluing and screwing the ring and this was to be used as the floor of the observatory. The waste corners were perfect for making the edges of the moulds. I decided I wanted to make one mould which could be used for each of the 18 segments. This was complicated by the fact that I wanted substantial flanges all the way around the inside of each moulding to bolt to the next one, the base ring and also the slit section. To get over this headache, I designed a 'brilliant' little gadget which I could transfer not only the angle at which each segment would strike the slit section but also the plane at which they would joint it. Using this gadget, I made numerous different aluminium ends which could be clamped

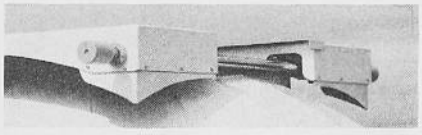
into position to change each segment without any alteration to the basic mold.

Having asked various questions about using fibreglass, I realized that the quality of the finish was totally reliant on the finish of the mould and so I lined it with smooth formica with removable plywood edges for the flanges. With the aluminium end sections in place, I added a plasticine filet between the finishing surface and the edges which would form the flanges (so that there would be no sharp edges and to allow neater finishing off with mastic) and finally applied numerous layers of mould release wax. I started my first segment; first a layer of white gelcoat (you have to work very quickly indeed with this!) Then lay-up resin and chopped strand fibreglass matting, followed by two more layers of resin and matting. As it started to cure, I trimmed the excess away and then left it overnight -- the next day I removed the edges of the

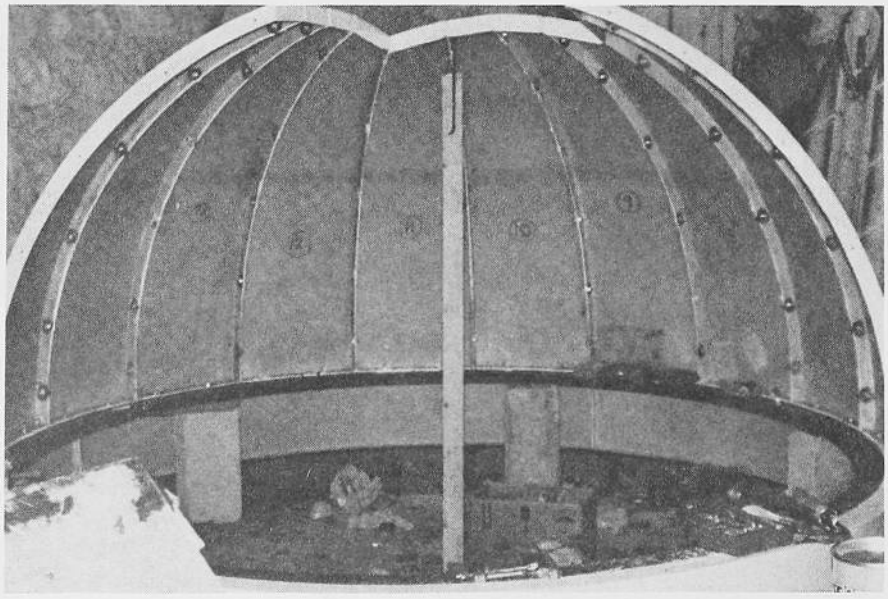
Above: *Small metal stops shape the ends of the mold segments.* ***Right:*** *A metal stop clamped in place,* ***Below:*** *Positioning the metal stop before casting a gore.*







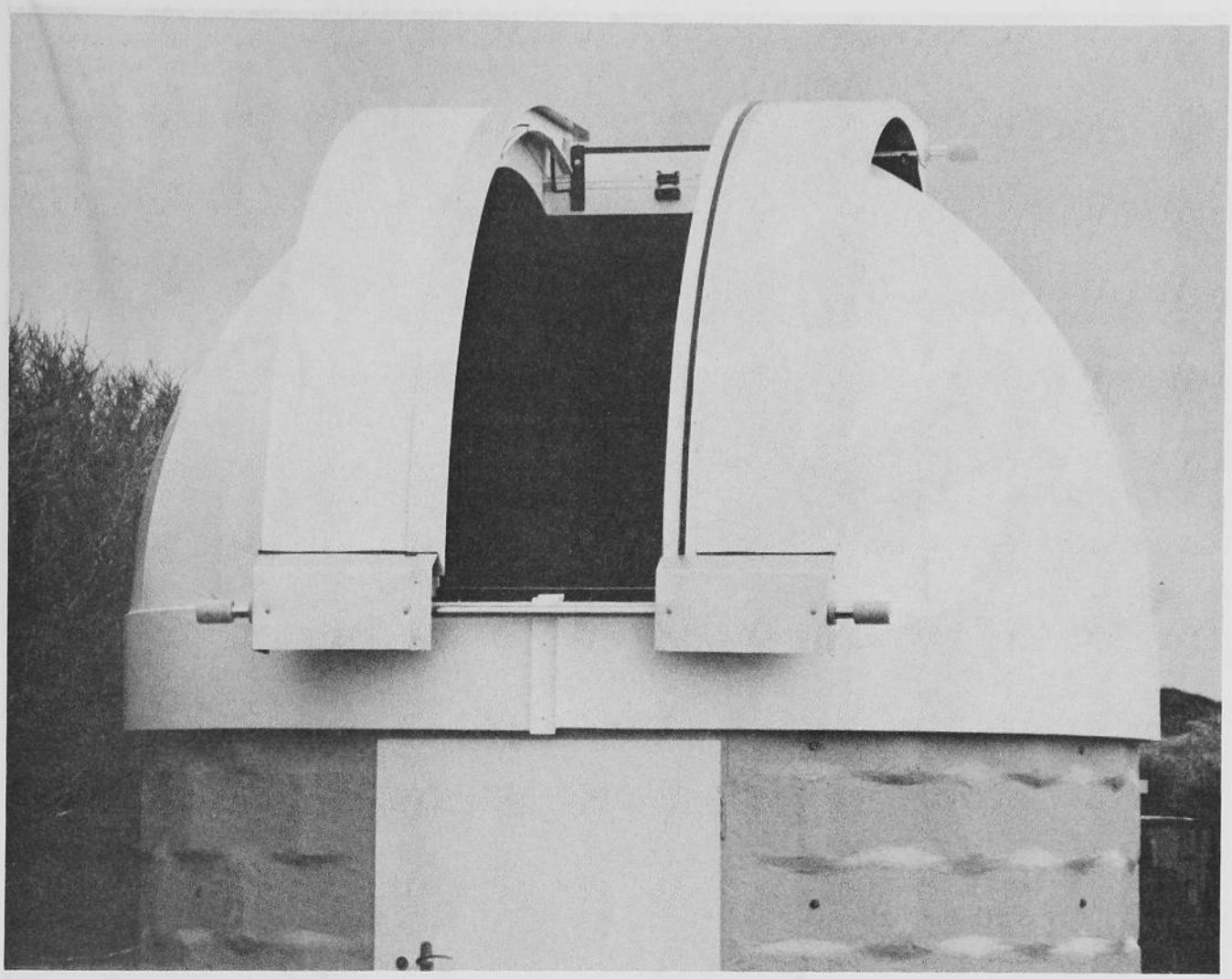
Above: *Bolting the slit frame into place.*
Left: *Detail of the shutter mechanism.*
Below: *Interior of the dome. Note that bolts hold it togehter. Joints are sealed with mastic.*



mould and released the moulding -- and low and behold -- one beautifullly smooth segment!

I then filed and sanded the rough edges of the flanges to finsh it off. Working at weekends and evenings, it took several weeks to complete all eighteen segments.

Having built one mold, I was not terribly keen to build two additional ones for the shutters and also the weatherproofing skirt, which would overhang the base ring and concrete block wall...and so I built one mould for the shutters with the same radius as the skirt and by blanking off a section of the shutter mould, made the two shutters. With all the fibreglass work finally done, I drilled, bolted and glued all the segments together and to the ring and skirt using a rubber glue/mastic. I then bolted in the slit frame in 3/4 inch marine ply. The whole structure is immensely strong. I then designed and built the shutter tracks with a stainless steel tube at the top and bottom for



Installed on its concrete block building at last! Note cowlings over the shutter mechanism. The dome is nine feet in diameter.

the rollers attached to the shutters to run on. I made aluminium cowlings to cover up the mechanism at the bottom, while the top shutter wheels etc., were concealed by the extended top section of the shutters. I added weatherproofing details and a pulley mechanism which meant that both shutters could be opened and closed squarely and simultaneously.

I then designed some adjustable brackets for the inverted trolley wheels to take up any slight unevenness in the block wall and some sturdy wheel brackets to keep the dome centered and from lifting. As these were quite heavy metal, a local forge made them up for me.

I cut out the floor from the remaining sheets of blockboard and then constructed the door which, just to make life easy for myself, had to be curved! (which also meant making an extra long key, special hinges and lock fittings etc.).

I had been constructing the dome in a garage about 14 miles from the observatory site and finally with the dome finished, the big day came for transporting it to the site and for a crane to lift it. Nerve-wracking experiences, both of them. The crane had to lift the dome over the roof of the garage and lower it carefully onto the circular walls and wheels (which I hoped would fit!) . Miraculously and narrowly, all went well and suddenly the dome was seated on its wheels...my own observatory was becoming a reality.

I added a friction motor drive using a surplus geared motor and added a control panel on the pier for the telescope drive, lights and dome drive etc. -- as there is no mains electricity at the site, I use a portable generator for power.

I have to say I am delighted with the finished product, it is a source of pride in my achievement and completely practical to use. Had I known at the very outset how much effort and commitment would be involved, perhaps I might not have started, but looking back I am so glad I did. I took things one step at a time and I think this was an important psychological detail which kept my sometimes flagging morale up during its construction. The whole project took about eighteen months.

The dome currently houses an 11-inch Schmidt-Cassegrain with an 8-inch Schmidt camera and I am currently working on an 8.5-inch f/3.8 Maksutov camera.

Terrence Tempest,
The Butler's Cottage,
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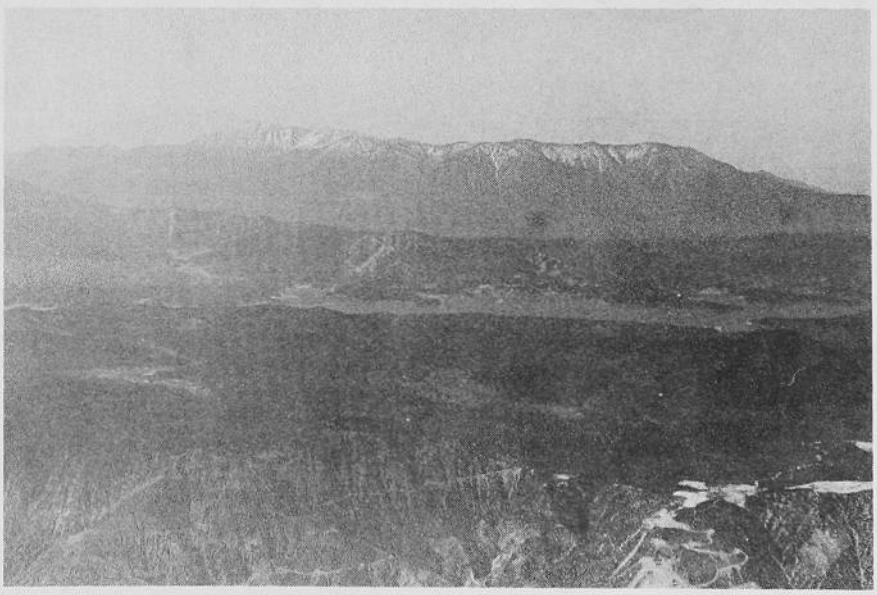
■

Meade
PARK

RTMC 1987

We swept in over the desert and saw the mountains ahead. I saw Big Bear Lake nestled among the ridges. From 22,000 feet the water was deep blue against the dusty gray-green of the mountains. I could trace highway 38 out of Big Bear City a few miles, but it disappeared from view before starting to climb toward Onyx Peak. As the 727 began its descent toward Ontario, we banked and dropped into the clouds that filled the valley. Minutes later we landed.

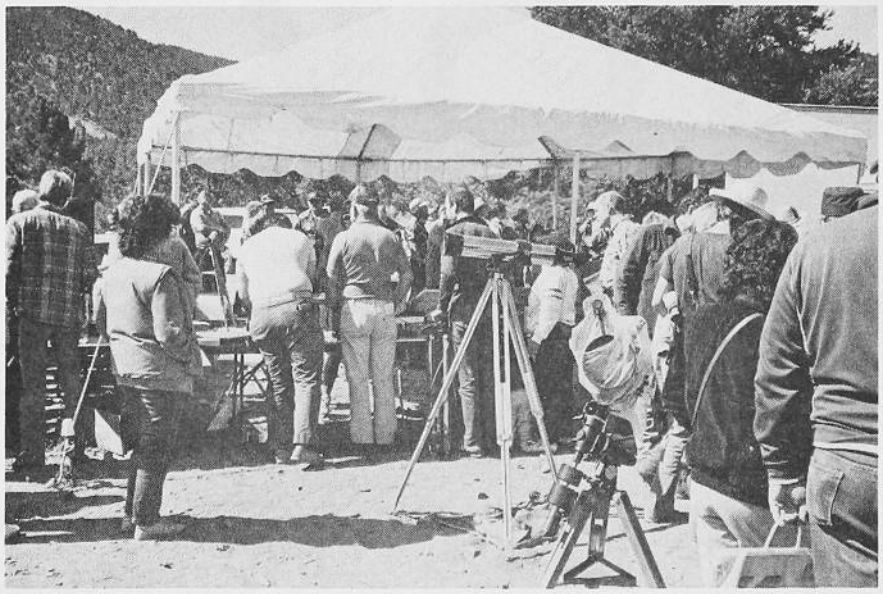
Two hours later I was sitting in a traffic jam on the road to Camp Oakes. The sweet odors of sage and pinyon pine mixed with gasoline, and the sun beat down on us all. The line inched forward a few car-lengths at a time toward the mile-distant registration table. There must have been five hundred people in line. I killed the ignition, got out, and stretched. In a pickup truck behind me in the line sat Chris Schur and his wife.



David Gedahlia stands behind his computerized alt-azimuth telescope. For an outlay of $200, David added stepper motors to both axes .

"Hi, Chris, what have you got under the tarp?" I said, peeping at the blue parts of what looked to be a rather large instrument.

"It's a 16-inch Newtonian," he said, "built for astrophotography." He showed me the oak-plywood declination bearings, which were readily visible, and then started to tell me about the tube he had rolled from a sheet of Masonite. To soften the material, he wet it. "It takes about a week to roll around the tube rings; you keep wetting it down, and you pull it around with ropes. The big problem is that it wants to form a teardrop shape, and you have to flatten it out." To do this, the ends are screwed to a stringer running down the length



Meade, Celestron, Parkes, Steve Kufeld, Questar, Kodak, Lumicon, Desert Sky, TeleVue, Coulter -- this list seems endless! This year the commercial exhibitors were more in evidence than ever before, yet the amateur telescopes remained accessible and well displayed. Despite a record crowd, auto traffic was very much under control.

of the tube. Once it dries, the Masonite regains its original hardness, and the resulting tube is both light and rigid.

An hour later I reached the registration table. It was obvious that an awful lot of people had showed up. I asked Cliff -- Clifford W. Holmes -- what had happened, and he told me that Camp Oakes couldn't open until 1 p.m. because the "Y" had kids there until noon. "They really meant it when they told us 1 p.m.," he said. "We couldn't let anybody in earlier." Then he added, "We've got six hundred preregistered, and I bet we're going to have two thousand people here this year."

Thus for me began the nineteenth Riverside Telescope Makers Conference, with the biggest crowd ever, and looking back now a few days later, in many ways the best ever. Cliff was right: over two thousand people showed up. There were lots of commercial exhibitors, and more than a few fantastic bargains. The swap meet was the best I've seen anywhere. Although it wasn't the best year for telescopes, several interesting instruments were shown, and I saw some very interesting developments in software. The skies were great on two nights, and the days were sunny and comfortable. All in all it was a very fine year.

I decided right away that my first priority was to find a half-decent bunk in a reasonably quiet cabin with a parking space somewhere nearby. Next, I decided, I'd have to hurry to the telescope field and join the feeding frenzy before all the good stuff was sold. I lugged my sleeping bag and suitcase into cabin #6, threw them on the cornermost bunk, and headed south.

Meade and Celestron had their booths set up at the upper and lower ends of the west side of the telescope field. Both were mobbed. My goal was binoculars, big ones. People were lined up three deep

Jeff Schroeder has constructed a very clever alt-azimuth mounting for his huge 11" refractor. Turning a crank by the eyepiece moves the jack mechanism to a maximum altitude of 63 degrees. In azimuth, the "rocker" turns on Teflon pads on a sheet of Micarta. The whole mounts on the roof of his car. Note wooden blocks under bumper.

around Meade's table. I leaned forward, looked, and saw somebody who had just purchased an 11x80 binocular. As he pushed his way out; I asked how much he had paid. $125. I craned my neck forward: there were quite a few more boxes behind the counter, so I headed for Celestron. They were selling "slight seconds" for $100 but were almost out of them -- so the question was how slight was "slight." There was a large trunk full of mutilated binoculars, eyepieces missing, lenses smashed, covers missing. One looked good except for a scratch on the body. I inspected it carefully for optical defects; it appeared fine.

Now you should understand Celestron didn't have enough people to handle such a crowd, and there were no prices on damaged goods. Mike Sugarman looked totally overwhelmed. "They're scratched," I said, waving the binocular at him.

"Make me an offer," he said.

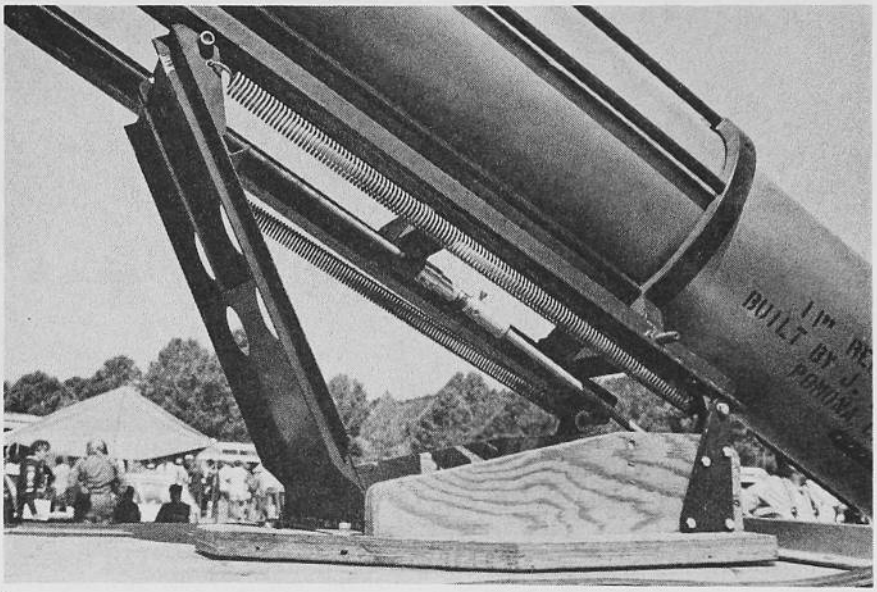
"Seventy bucks!"

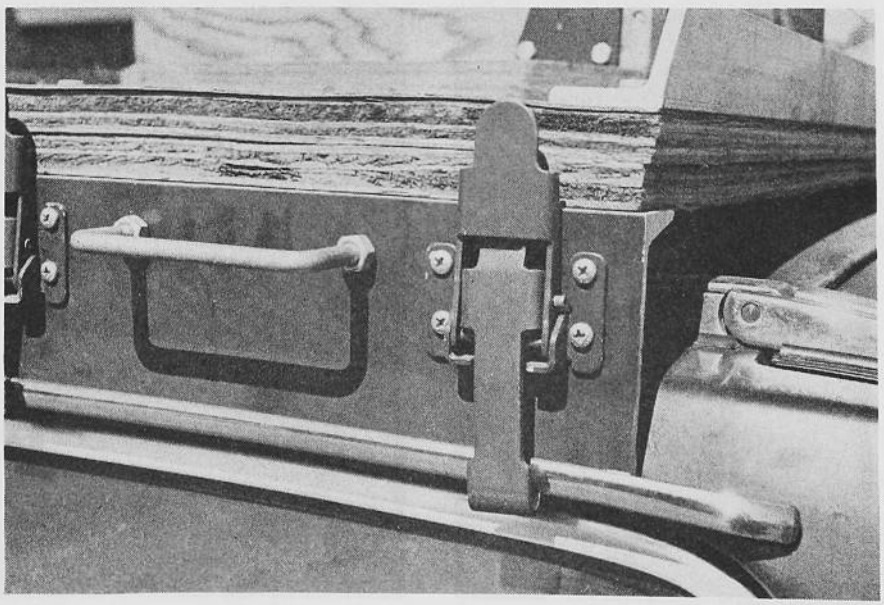
"Done," he said.

I wrote the check wondering if I should have offered $50, or $30, pleased nonetheless with the value I'd gotten for $70. *C'est la vie.*

Amid the commercial frenzy the field was slowly filling up with telescopes. Equatorials, I noted, seemed to be enjoying something of a resurgence this year, and there was fair sprinkling of refractors too. In the commercial realm Parkes has joined the Dobsonian revolution with a line of telescopes that look like kitchen counter tops. Coulter has redesigned its line, and glued the mirrors into the mirror cells. Beside the observatory was a prominent CAT booth with its cocky smiling feline face.

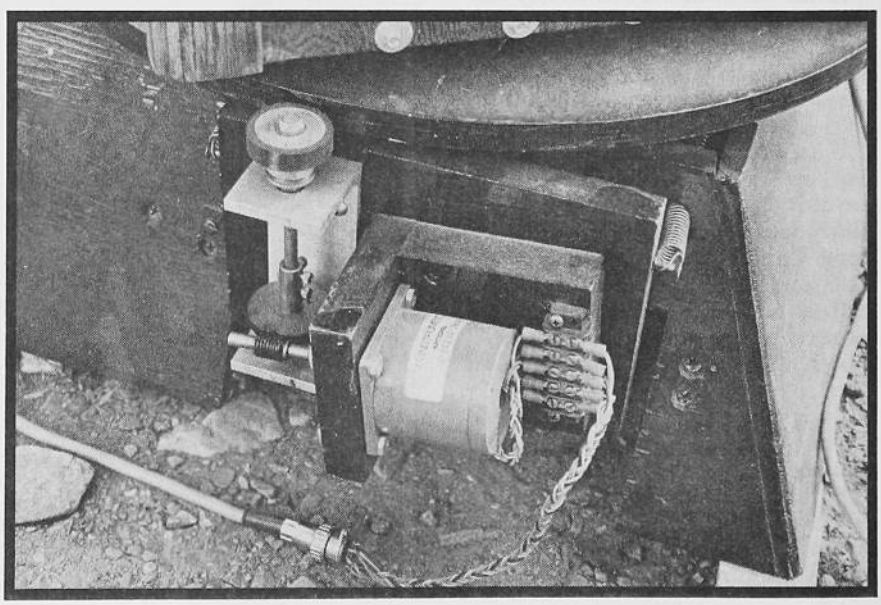
After dinner I went back to cabin #6 for some warm clothes and then returned to see the evening program. The line was so long I decided to skip it and ended up sitting around and talking with people, among them Norm





Steppers mounted in spring-loaded wood frames move David Gedahlia's Dobsonian. Azimuth axis uses low-friction "lazy-Susan" bearing.

Computer Control for $200...



Sperling. Although Norm runs Everything in the Universe, mostly he was selling back issues of a certain magazine he once worked for. I bought some unbound plates from the *Harvard Annals* -- great stuff at a dollar apiece.

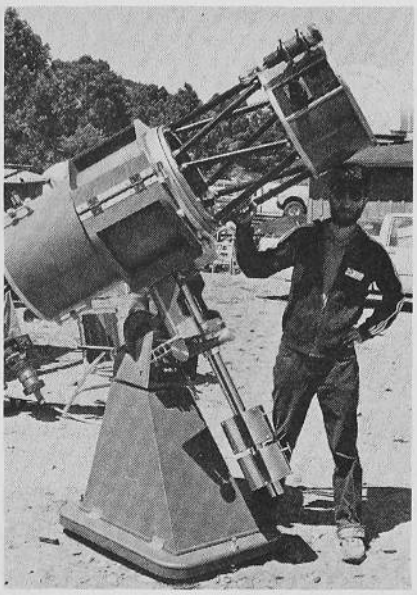
By the time I headed for the telescope field, the sky had turned a little hazy. I walked around sampling views though a variety of telescopes, perhaps a dozen in all. One sticks in my mind, though, an 18" f/6 telescope named Never Again. The fellow who built it had taken a class from John Dobson of the Sidewalk Astronomers, and, without quite knowing what he was getting himself in for, decided on an 18-incher. He'd gotten an excellent figure on the mirror and finished the telescope only weeks before. So here he was at the RTMC trying to find M-65 and M-66 in Leo. He didn't have a star atlas of his own and was trying to find them with some half-remembered instructions from a friend. For a finder he had a 60mm refractor giving about 30x mounted on the rocker box. I thought it was going to be pretty hopeless To my surprise the "overpowered" finder was very helpful because I spotted our quarry in it. It just shows you learn every time you try something, but I advised him to get a low-power finder too.

By 10:30 or so my feet were getting numb and I was having trouble staying awake. I decided to take a quick look at the CAT before turning in. Behind it, beside the observatory, I notice an odd orange glow, which turned out to be a Macintosh computer with a piece of orange cellophane over the screen. Somebody would point and click at a map on the screen, and a 12" telescope about ten feet away would buzz over to the object.

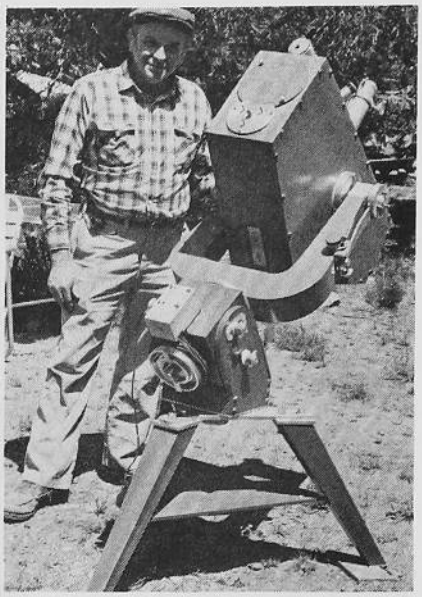
I leaned over the person operating it and stared at the screen. He had a star map on the screen. He would bring the mouse to an object, click, and the telescope would move to the object. My feet were suddenly warm.

I don't know what I did -- maybe I just pushed the guy off the chair -- but within minutes the mouse was in *my* hand, and I was driving the slickest bit of computer control software I've ever seen.

The guy who wrote the software and built the telescope turned out to be Tom Mathis (of drive-gear fame), and the program turned out to be something he's been developing for the navy, to drive two C-14s for site surveys. "I've had it for quite a while," he told me, "and I'm a fan."



Chris Schur and his 16-inch equatorial. Chris rolled the lower part of the tube from Masonite by repeatedly soaking the material.



Gerry Logan with his 6-inch Tri-Schiefspiegler mounted in an equatorial fork. RA has a chain drive for smooth tracking.

The next day I found Mathis currently has about 4000 deep-sky objects in his database; he put them in whenever he gets a little extra time. For the stars, he was using the STARS.DAT stellar database I wrote up in the September 1985 ASTRONOMY. I was pleased to see it so beautifully employed.

It was getting late for someone who had gotten up at 4 a.m. the previous morning two time zones east of Big Bear, and the cold was creeping in. I said good night and headed back to my bunk in cabin #6.

Saturday morning arrived too soon, but the mountain air was cool and crisp, and it was good to fell the warm morning sunshine on my face. How good coffee tastes , too, when your body is telling you that you slept too little. I hurried over to join the breakfast line. Chow!

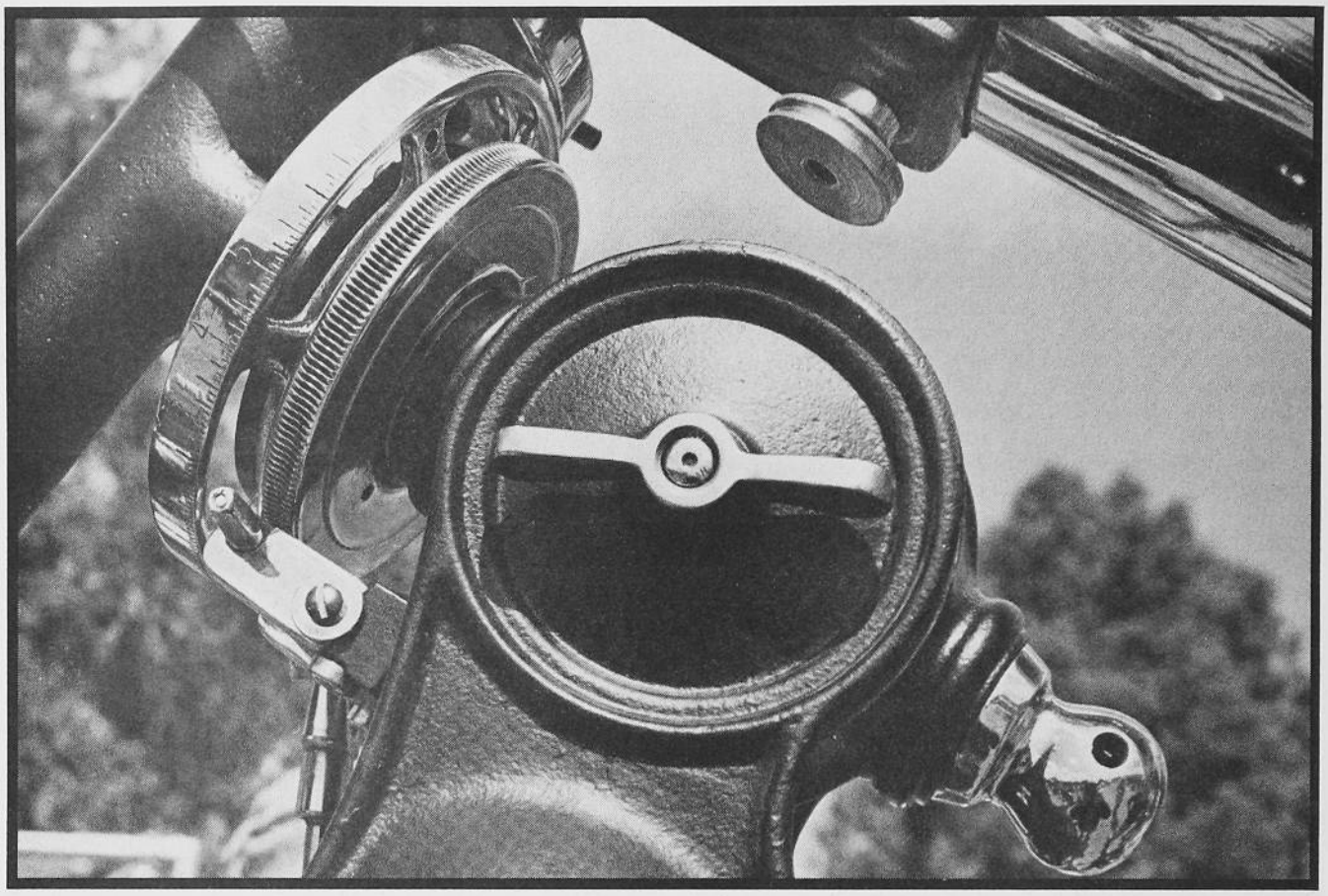
I like to know what happenes to unusual and interesting telescopes. This year Jeff Schroeder brought his 11" f/16.3 refractor, and it wasn't on the tall equatorial mount he'd had it on when I first saw it. Instead it was mounted on the roof of his station wagon, on an alt-azimuth mounting. He clearly liked the new arrangement. "I've gotten more use out of this thing in the last two years," said Jeff, "than I did in the previous ten." Comet Halley had inspired him to make it easier to load and unload from his car, easier to set up, and easier to use with the general public. Loading the tube takes about five minutes; attaching the platform about the same time. "I figure I showed at least seven thousand people the comet through this thing," he said.

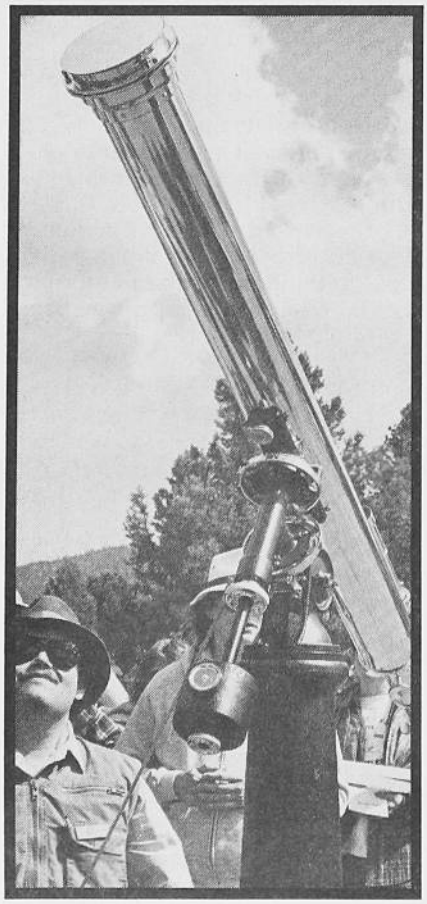
I recognized another familiar face in Gerry Logan, though I couldn't quite place him at first. His 6" Tri-Schiefspiegler was based on Al Woods' design in *TM#16* -- in fact, Al had visited him only a few months before. "I didn't have too much trouble with collimation thanks to Al's article. I looked at the chain drive on the mount: "Didn't you bring that Jones-Bird a couple years ago?"

"Oh yes, and I had an 11" Maksutov camera several years before that." Bingo -- now I remembered.

He had done a nice job with the tube; it was finished in cherry veneer plywood. The mount and tripod were also finished nicely. "Those are just ordinary 4x4s under the veneer," he told me, "and the fork is fiberglass."

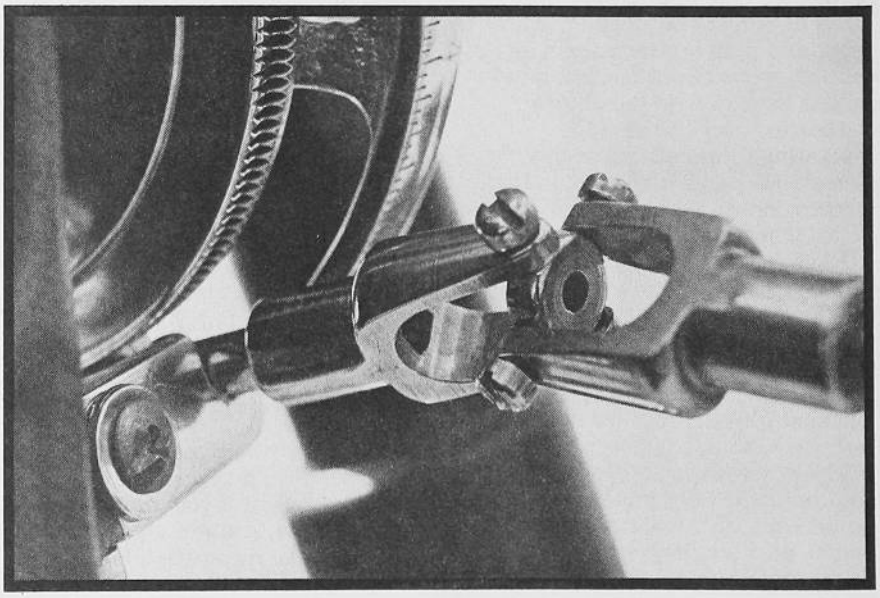
In contrast, Dave Trott's stuff looked crude. It was constructed

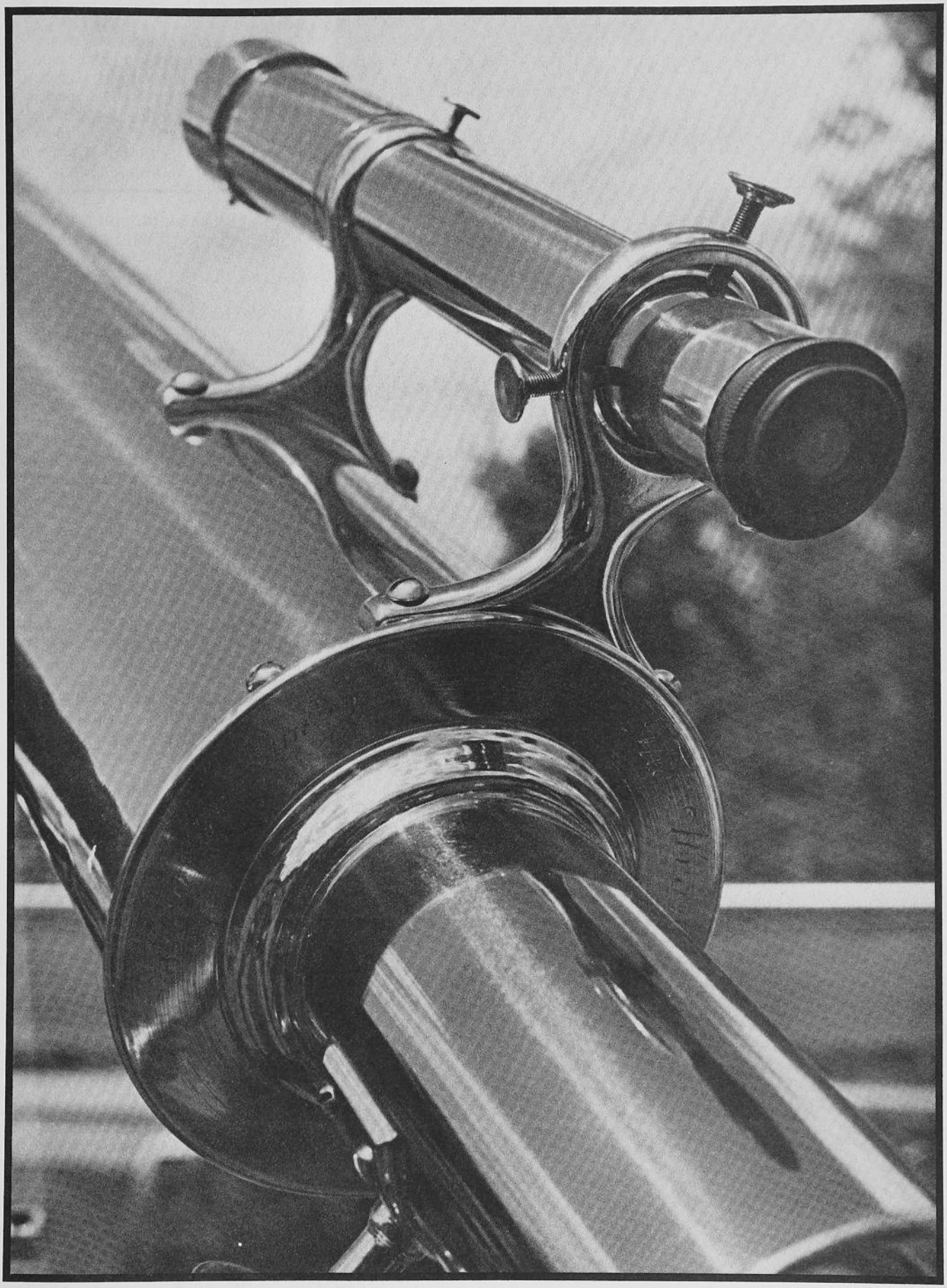


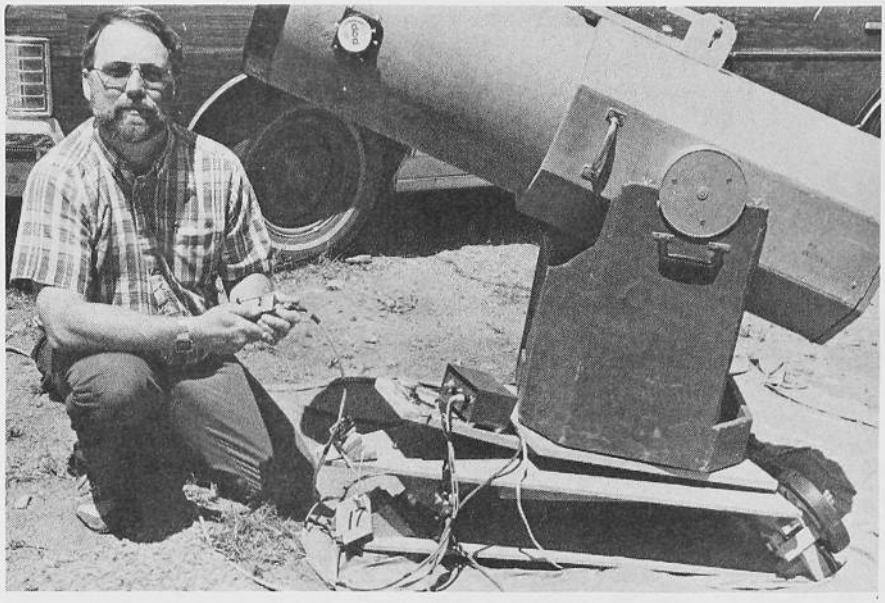


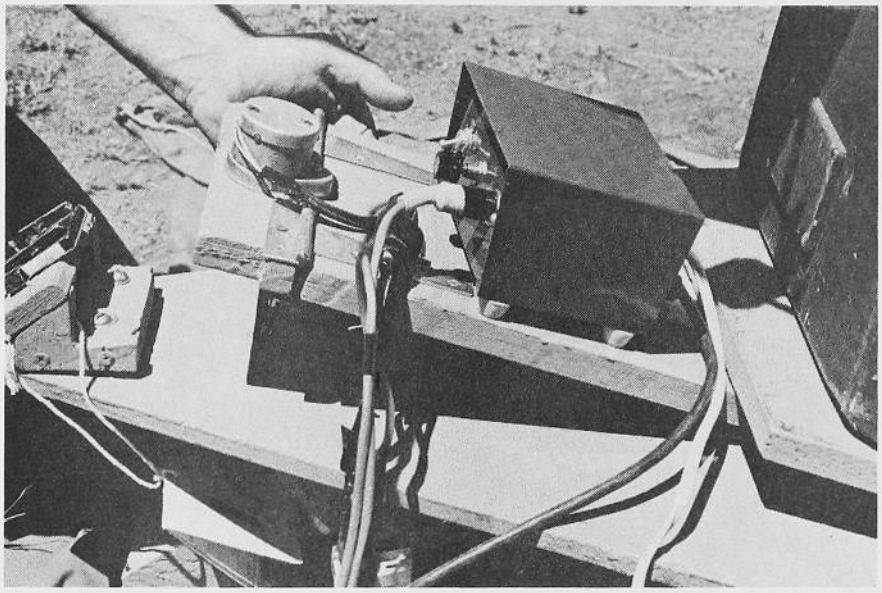
The Gleam of Old Brass

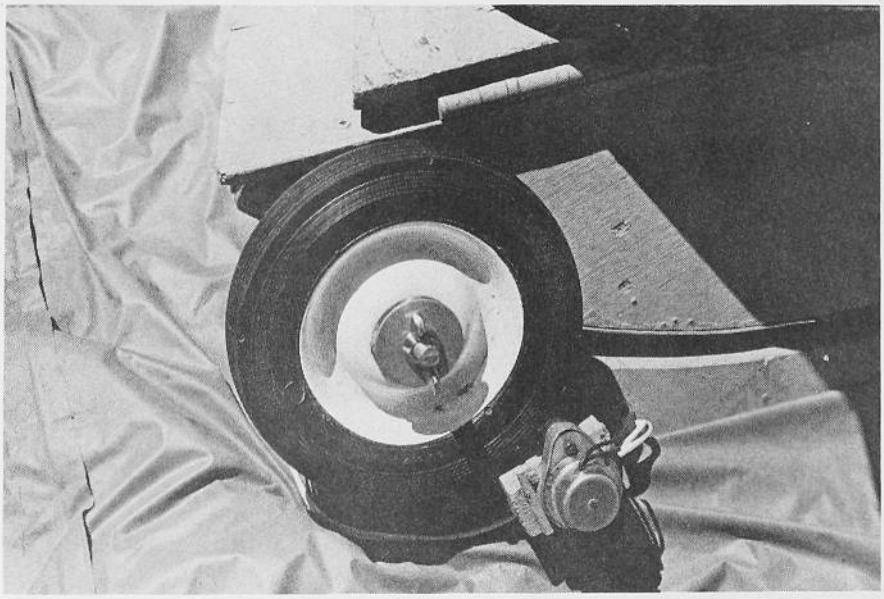
"Cambridgeport, Mass" reads the inscription on the tailpiece of Luis Ashelford's restored Alvan Clark beauty. Ashelford made new knobs to replace missing ones, but made sure the new ones were matched style of the old. Universal joint takes RA control rod "around the bend," like the original.











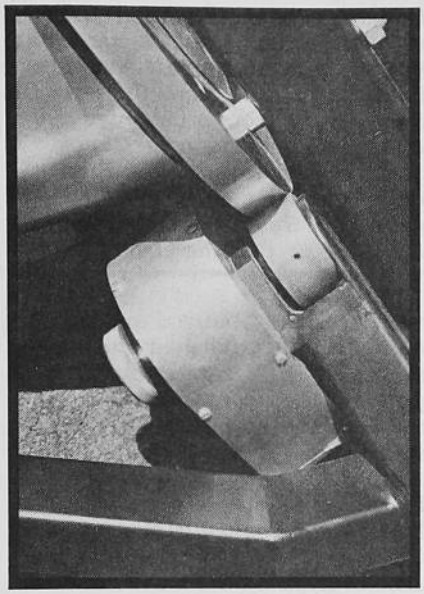
Dave Trott built this equatorial platform for his modified 13" Odyssey an has been doing astrophotography with it. Features include pseudo-declination axis slow motion (middle photo) and wagon wheel drive. The platform is one of the Pursell variety, with a large-diameter sector turning on rollers. The radius of the sector is 43".

from particle board, and finished in institutional green and pink paint. "It's all hardware from the hardware store," he told me, "it looks awful but I'm getting results." What he had was most a standard Odyssey 13" f/4.5 Dobsonian mounted on an equatorial platform equipped with a pseudo-declination axis. He had pictures to show it worked, and, while not perfectly guided, the pictures looked promising. I hunkered down to take some close-up photos. "Have you met Dick Housekeeper?" I asked. Yes, he had, just a few minutes earlier. "His article inspired me to build this."

The cleverest feature on the telescope, at least to my mind, was the reducing train for the drive. Trott had a modified Poncet platform (a Pursell platform) with a 45" radius. It ran on one support roller and one driven roller and piece of 1/2" line shafting. This had a standard 8" rubber wheel mounted on it. This in turn was driven by a spring-loaded 1/2" shaft on a 1 rpm synchronous motor.

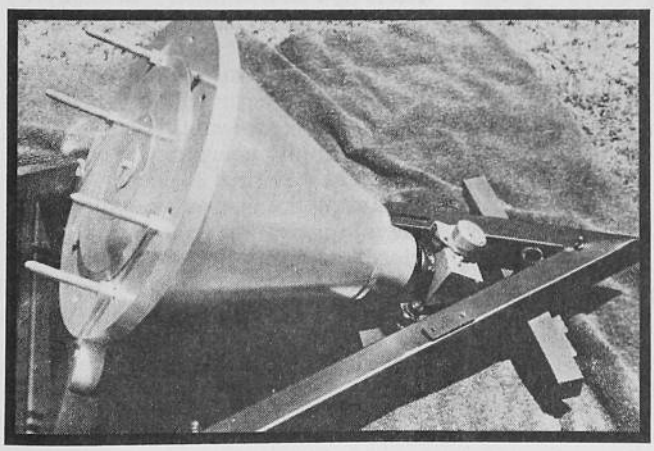
Trott also had a compensated lever tangent arm drive. Although there are several ways to do it, he had chosen the mechanically simplest. A linear bolt driven by a motor lifts one lever, while the second camera-carrying lever rests against the first and slides on it. Trott had optimized the lever pair to give a long tracking time without introducing tangent-arm tracking error. His piggyback shots appeared to perfectly tracked.

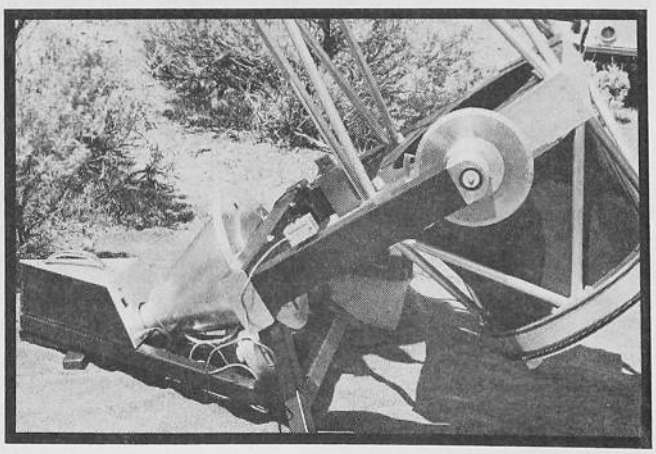
Along the north side of the playing field were six or seven tents set up by some of the smaller vendors. I bought a Tel-Rad finder from Steve Kufeld (I've wanted one for years) and then turned to inspect a beautiful 4" f/15 brass Alvan Clark refractor brought by Luis Ashelford of Los Angeles. "It took me a year to restore it," he told me. He had pictures showing the heavily dented and partially-electrified telescope he had started

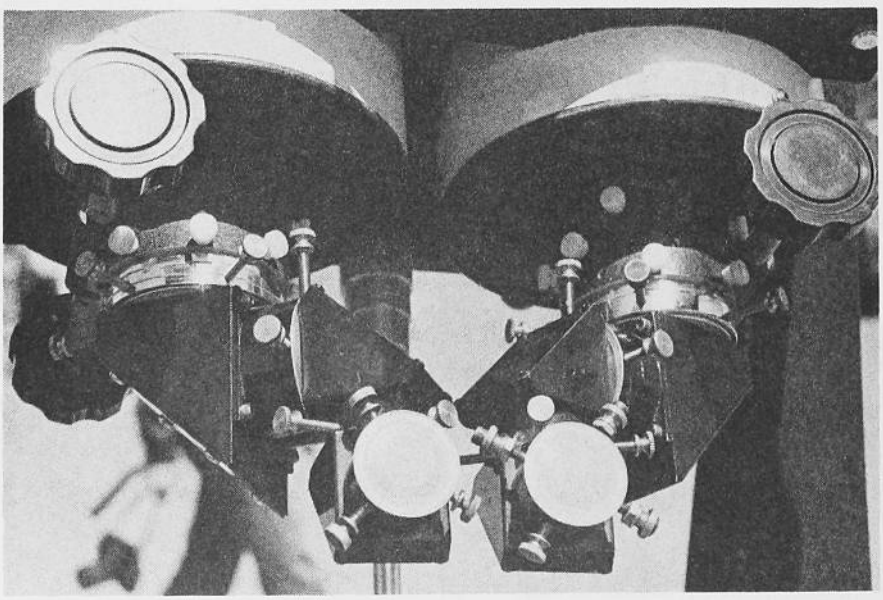


Even for the machinists, in the TM community, friction roller drives seem to be one of the best and easiest ways to build a high-quality RA drive. Bob Pfaff constructed this fork-mounted 17.5-inch Newtonian from steel box beams. The base is 2x2 material: note the short, direct path vibration follows to the ground. The cone is built from a 4-inch diametr pipe and a large aluminum disk, then filled. Twin rollers support the massive conic polar axis ; the eastern roller is driven. Just in case you were wondering, that little box at the south end of the polar axis houses a massive counterweight as well as the drive electronics. The telescope tube is one-inch light-wall aluminum tube. This mount is exceptional solid and free of vibration.

A Mounting Both Solid and Simple







Donald Rothman displays his big refracting binocular. Twin Jaegers 6" f/5 objectives provide enormous light grasp. The optical train is made entirely from commercially available star diagonals. Clamp screws are necessary to maintain alignment. Mounted in an upended C-14 fork, the instrument moved smoothly around the sky.

with. Ashelford banged out all the dents by hand, polished it to a high shine, and then coated it with polyurethane to protect the yellow metal. Many of the fittings were made of rose brass. "I reproduced all the knobs that were missing," he said, "this one, this, here, and here," as he pointed to about two-thirds of the total. To improve the ease of gripping the narrow rims of the originals, he had given them wider rims, though they were done in the same style as the original. I've had many inquiries about restoring old telescopes, so I asked him to write up his restoration techniques for *TM*.

Many of the best telescopes are hidden down "Telescope Alley," where intrepid writers may not see them. This year I saw Ron Hill's beautiful observing set up. This centerpiece is a 17.5" f/4.5 open-tube Dobsonian finished in dark-stained wood with green and white trim. What attracted my attention, however, was a clever chart stand with a built-in bookcase and a nifty little two-step ladder. Handy accessories like these often make the difference between a telescope that gets used and one that stays in the garage on clear nights.

The most exciting telescope I saw at Riverside this year was a modest 10" f/4.5 Dobsonian. What made it interesting was its control system. Driven by stepper motors attached to both axes under the control of an Atari 800XL computer, this simple and inexpensive instrument automatically slews to an object selected from a menu on the computer screen. Built by David Gedahlia, a sophomore in electrical engineering, the entire unit cost $200 out of pocket, excluding the computer, which had been languishing on a floor of his closet, and therefore probably qualifies as "from the junk box." Does it work? "I looked at eighty or a hundred objects last night," said David, apologizing a bit because he hadn't been counting them, "Yes, it works."

Ron Hill stands beside his ever-so-handy illuminated chart and equipment table. His telescope and observing ladder were equally fine.

Stepper motors on the azimuth and altitude axes drive large (approximately 18-inch diameter) wooden friction wheels through rubber wheels. The steppers are reduced through small surplus gearboxs; the motor, gearbox, and rubber wheel are spring-loaded against the friction wheels. The friction wheels were cut on a bandsaw with a nail for a pivot. The 5-volt steppers, the most expensive part of the project, and all the other mechanical parts were surplus.

The control program is written entirely in Atari BASIC, except for some machine language motor-driving routines. "Software takes care of all the ramping up and down," said Gedahlia. The computer controls the motors via the joystick port; these low-current signals signals are amplified by means of an auxiliary power supply and motor control box. At Riverside the telescope sat about eight feet behind the tailgate of Gedahlia's station wagon; the computer, disk drive, and control boxes were on the tailgate. I found it difficult to believe a disk drive can function in so dusty an environment, but it apparently did.

For the future, Gedahlia plans to have the system automatically track an object, as well as find it. He plans to rewrite the program so every ten seconds or so the computer goes to the same object, returning it to the center of the field.

"It isn't too accurate if you try to point at a new object 120 degrees away from your starting point," said Gedahlia, "but it does okay within a 60-degree cone." He attributes most of inaccuracies to mechanical problems in the telescope mount. "The axes aren't perpendicular," he noted. The telescope has an open-loop control system.

I liked this system because it's within the reach of a large number of people. A few simple circuit boards, an old game computer, some high-quality, low-cost surplus steppers, and a mechanically simple telescope could really be of service to a serious amateur astronomer doing, for example, variable star estimates for the AAVSO or searching for supernovae in bright galaxies. By reducing the time needed to find a given field to a few seconds, the observer can carry out a more ambitious program.

That evening the longest line ever formed at Riverside stretched from the dining hall along the concrete walk, across the dirt road, past not one, nor two, but three of the dorms -- and more people were still coming. By the time I finally squeezed into the dining hall, it was packed wall-to-wall. I wormed my way forward and found a seat where I could follow the proceedings and take notes. Several hundred people remained outside.

Ashley McDermott opened the evening with a few announcements, then Cliff Holmes took the mike to the cheers of the crowd. "Yodel-ay-ee-oh," he sang, and welcomed those of us packed into the hall and those watching on closed-circuit TV outside the hall "I don't know how many of you looked at your program," he began, "but I want you to notice that this conference is dedicated to the memory of Don Rohe who passed away last September and Pat Michaud who died this March. These fellows were fifty and forty-eight respectively," he reminded us, "and we aren't going to forget them." I knew Don as the organizer of the Big Bear IAPPP several years ago and as a willing contributor to *TM*. Pat had supervised the telescope field and in his own gruff

sort of way kept the merit award hopefuls in line. How recently I had photographed him beside the gleaming brasswork of the vintage refractor mounting he had restored.

Rick Shaffer then took the podium, and, after explaining the concept of the Bozo Award (the very first Bozo Award was given to Ed Byers for wearing a jacket and tie at RTMC), announced that Pat Michaud would receive a posthumous Bozo Award "for acting the Bozo when people tried to enter projects in the merit award competition that could qualify for nothing but a 'best use of catalogs' award."

Tom Johnson and Mike Sugarman then presented the first annual Celestron Awards: best astrophotography to John Gleason, best public communications project to Peter Manly and the Saguaro Club, best new product idea to Stanley Comparesi, and the small telescope observers association award to Robert Browning. Each winner received a super C-90 Astro telescope.

The door prize drawing began with a 16mm Nagler type II, continued with at least thirty other products, goods, and services, and then wrapped up with two C-90s (and all the accessories) and the grand prize, a Meade 2080 LX-5. Meade's John Diebel gave a little speech praising Cliff for "the best-run and friendliest conference Meade goes to," and then briefly described the features of the LX-5. "It has a retail value of $4,100," said John. We sat on the edge of our seats, and the winning number was drawn and called: 5..1..0..3..4..9. With a squeal, Mrs. Jaye Silver jumped up holding the winning ticket.

Early in the day Pete Manly had come to me with rather odd question: "Do you have a T-mount for your camera?"

"No," I said, "I use just one lens, a 28-70mm zoom. Makes for easy traveling.

"Well, I have an image intensifier I'd like you to try. It mounts on any camera with a T-mount adaptor. After some dickering, Pete realized a friend of his would have the proper adaptor.

So, as the sky grew dark, I met Pete and looked at his little gizmo, a Litton M911 pocket scope. (Pete works for Litton, a company smart enough to realize there's a market for these devices in amateur astronomy even though they cost several thousand dollars apiece.) Anyhow, it was about 8 inches long by 1.5 inches diameter with a slight bulge on the side for

batteries.

We attached the device. On the front of the intensifier was an f/1 objective lens; on the back a relay lens to re-image the glowing phosphor screen back to the film. I decided to let the automatic shutter in the T-70 decide what exposures to use; it's been very reliable in everything else I've tried and works at low light levels.

"Great," I said, "see you later."

Pete then informed me he would have to follow me around because it is illegal to use a night-vision device in California unless you are an educational institution, a representative of a firm that makes such devices, or a law-enforcement officer.

"Okay," I said, "let's go." We marched off into the dark.

I turned on the device.

I pointed it at Pete.

"Wow!" I could hardly see Pete in the dark, but the meter said 1/8th of a second of Tri-X. I pressed the shutter button; it sounded like an 1/8th.

"Do you want a tripod?" he asked.

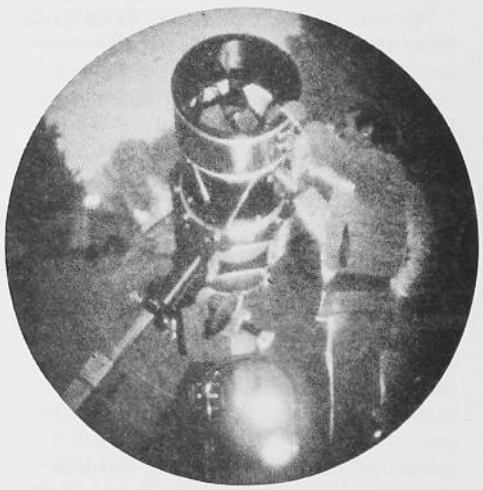
"No. I'll hand-hold."

So that's how I came to spend most of an evening photographing amateur astronomers observing through their telescopes by ambient starlight. The pictures tell the story. I photographed Chris Schur searching for Comet Halley that night (he found it), Ben Mayer showing a couple of pretty girls how to find the constellation Virgo with a Star Frame, Ron Hill looking at M-13 through his 17.5" telescope, and then took a hand-held shot of the same object by holding the lens up to the eyepiece and shooting. What a device -- handheld photos of deep-sky objects!

Scorpius and Sagittarius were high in the sky when the cold and long hours finally caught up with me. The last thing I did before turning in was to slowly scan my new 11x80 binoculars along the rich star fields of the Milky Way.

Sunday dawned considerably too early for my taste. Sometime around 7 a.m. I rolled out of my sleeping bag and shaved, showered, and got dressed. The morning air was chilly, but the sunshine felt warm and good. I like Camp Oakes early in the morning with the smell of bacon and coffee on dozens of little camp stoves. My own breakfast waited in the mess hall.

The morning event was a talk by Clyde Tombaugh. Carrying my little notepad, I made my way to the front and sat down beside Janet Mattei and a young man she introduced as Bahadir Erimli, a seventeen-year-old Turkish high school student on a ten-day astronomical tour of the United States. I could not help but wonder how an event as distinctly American as the RTMC -- and quite a circus even by American standards -- must strike someone from an entirely different culture.



The Mattei's, Janet and Mike, were Bahadir's hosts here.

On behalf of the New Mexico State University Tombaugh Scholar's Fund, David Levy introduced Clyde gracefully as "a drawer of planets; that is, he made drawings of planets." And, as we all know, Clyde also drew Pluto into

his net.

Clyde is refreshingly blunt. "I'm not going to give you my usual spiel because you people know about observational frustrations," he began, then he re-created for us the chaotic environment he had, as a young man, plunged into fifty-seven years earlier at Lowell Observatory, with a poorly planned program, finicky equipment, glass plates that blew up when bent to the Petzvel

curvature of the Pluto camera, and the Delta Geminorum jinx.

And the blinking. "I dreaded blinking those plates," he confessed, "but it was better than pitching hay back on the farm."

Later in the day Clyde would win the Clifford W. Holmes Award for contributions to amateur telescope making, an award presented to me several years ago. The picture of Clyde with his 9" reflector down on the farm in *ATM*, has probably inspired as many *TM*s as any other picture in the history of amateur astronomy. Said Clyde: "The Smithsonian asked me for my 6-inch telescope, but I told them 'No, I'm still using it.'"

After the applause died down at the end of the talk, Cliff presented Clyde with a canary-yellow RTMC cap. "Now you see," said Clyde, "I'm really one of you."

That morning I stopped by to look over Robert Pfaff's solid equatorial mounting for his 17.5" f/4.5 reflector, somewhat hidden off the southeastern corner of the telescope field. Too often fork mounts are wobbly, but Pfaff has made one that's unusually solid. I tried to figure out why this one worked well when so many welded steel structures are so springy. He had kept the path to ground short, he had used heavy cross sections, and he had filled the equatorial cone with energy absorbing material. Were these enough? Apparently so.

In the dusty center of the telescope field I found Art Leonard's Solano 6-inch f/10 reflector. Art has been promoting this three-mirror unobstructed reflector (concave-concave-convex) for several years. He told me that Steve Johnston (see *TM#28*) would be showing a 12-inch f/12 Solano telescope at the TSP (see "Optical Experts Comment on the TSP," in this issue). When I asked if he'd had any extraordinary difficulties in building the 6-incher. Art admitted that, yes, he had had problems: "After I tried to collimate it the first time. I sat down and thought about, and I realized I had to build a whole new case." He stressed the difficulty in aligning three-mirror systems in general: "There are five components to be positioned in three axes, so that's fifteen adjustments, or twelve independent adjustments since they're relative," he said. Apparently Steve Johnston had solved the problem, but it may remain as a trap for the unwary.

By now the sun seemed quite high, and I realized to my chagrin that I had, in fact, missed lunch by about an hour, and the time for my scheduled talk was fast approaching. I grabbed a bit at the water tank snack bar and headed for the meeting hall.

Cliff Holmes had called me a week earlier and asked if I wanted to give a paper. I told him I hadn't

been planning to, but by the time I put down the phone, I was committed to say something.

My talk was on recent trends in telescope making. I observed that we telescope makers are, for the most part, an aging cohort, and that I didn't see a lot of youngsters

getting into the field. I noted that I saw two predominant quests in the field today: one for an equatorial as easy to build and as solid as a Dobsonian mount, and the other, a quest for optical quality, for optical perfection. "The SCT's just don't have it when it come to optical quality," I said, "especially once you've gotten spoiled with a medium- to big-size refractor. Nor do the big Dobsonians deliver the kind of images we'd like to see."

I bemoaned the lack of support for telescope making from the companies that sell astronomical goods. "Mirrors are priced artificially high; the outfits that sell them appear to be trying to make building a telescope significantly more expensive than buying a second. This is good for profits in the short run, but I believe that someone who builds a telescope gets hooked for life. That's not true of people who buy them. The commitment's lacking."

Of course, the rising quality of commercial scopes also undermines the urge to build, and commercial scopes are, on average, better than ever. And there are fewer people around who know anything about machining. That's one of the factors that made the Dobsonian, and something I had to take into account when I wrote *Build Your Own Telescope*.

I have also noticed a significant trend away from astrophotography. Some of that probably stems from the decline of photography as a hobby, and some of it from a "seeing is believing"

Art Leonard stands behind the prototype Solano reflector. This 6-inch three-mirror system has unobstructed, all-reflective optics.

attitude on the part of modern deep-sky observers. It's curious that this trend should develop at a time when the films are faster, finer-grained, and reciprocity is readily countered. And, of course, I mentioned computers and the striking progress we're seeing in automated finding.

After the talk I spent a pleasant couple hours relaxing and talking with George and Nicki Keene. George works for Kodak and has consulted for Bushnell; we'd met on the Stella Solaris last year but never had a chance to sit and shoot the breeze. I also wanted to save up some energy for the coming night, which promised to be clear.

After supper I attended the merit awards ceremony which, as has become customary since the "Maurice" mysteriously left a Pasadena junk yard and came to RTMC, follow the Bozo Awards. This year's Bozos were Bob Ferguson (for "Success in Cloning Telescopes"), Gene Sticks-to-Your-Elbow-like-Velcro Lucas for his helpfulness to the awards committee, and Randy Wilcox won his glow-in-the-dark Frisbee for Outrageous Overdressing at Riverside (I think).

Randy Wilcox explained that the philosophy behind the merit awards is to recognize outstanding achievement, not rank in preset categories. Each member of the award committee would present three or four awards.

Bob Schalk then recognized Louis Ashelford for his restoration of a Clark refractor, Ben Morgan for his effort in modifying a a mounting, Alan Takahashi for his collapsible 6-inch Newtonian backpacker's telescope, and David Wile, a unique lightweight telescope.

Pierre Schwaar (designer and producer of the Bigfoot mount) expressed his disappointment that this year, despite a record attendance, there had been only thirty entries for merit awards. An honorable mention went to David Schwab for a modified Poncet platform, recognition to Steve Collet for craftsmanship with simple tools, and for what Pierre called "the most creative handwork" he saw this year, a merit award to Ronald Hill for his integrated observing station.

Paul Zurakowski from the Chabot club gave an honorable mention to Kenneth Applegate for a collapsible 10-inch Dobsonian that uses ball-in-socket connectors, and merit awards to Jeff Carmak for the unique ventilating system on his 17.5-inch Dobsonian, Leonard McVickar for his stable and well damped ball mounting, and Bob Pfaff for his 17.5-inch Newtonian with a friction-roller drive.

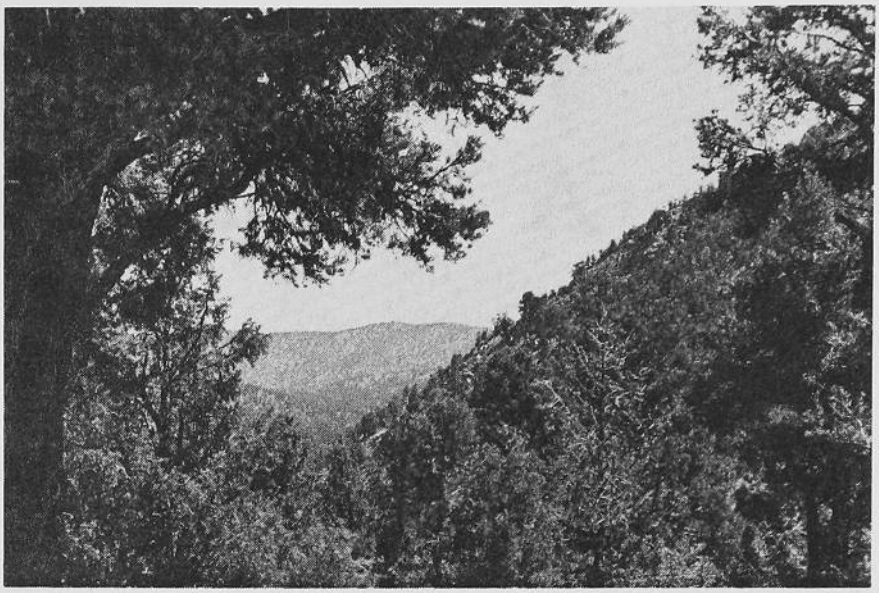
Rick Shaffer presented Bob Ferguson with an honorable mention for his "almost indestructible kid telescopes" built in his youth telescope project. (Ferguson has built twenty-two of these instruments; as noted above, he also received a Bozo for "cloning" the design.) His computer controlled telescope mount brought David Gedahlia a merit award, and Chris Schur's sturdy lightweight tube-rolling technique was likewise recognized.

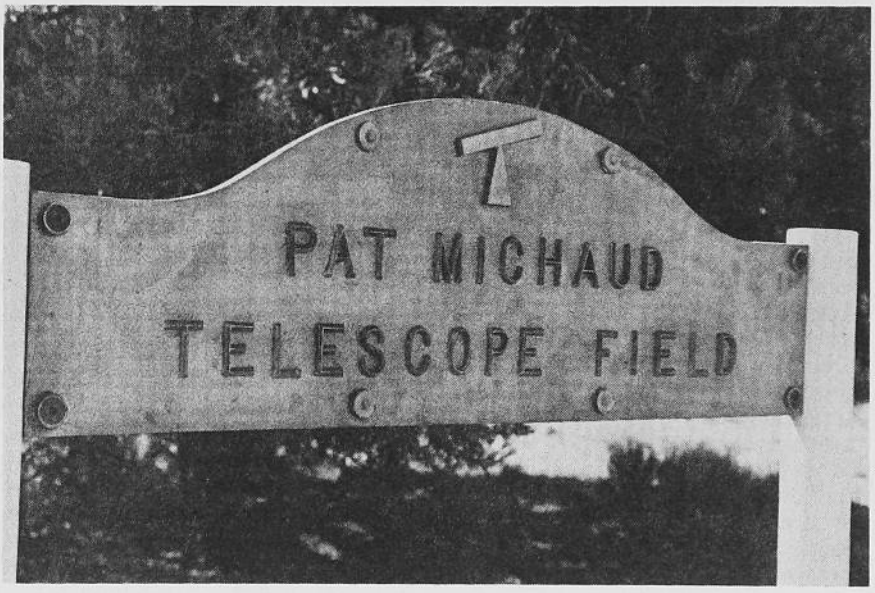
Finally, this year's Warren Estes Award for the best use of "junque" in a telescope went to J. Winford Tucker for his rotating observing chair and binocular stand.

It was now 1 a.m. I was cold and tired, and my feet ached. I noticed a bluish flickering beside the observatory -- Tom Mathis' Macintosh. I went over; he was observing alone. And in the forty-five minutes that followed I glimpsed the future.

Mouse in hand, I sat in front of the screen and called up a starfield

Lest we forget: RTMC is sheld in a beaututiful place. And now the telescope field has been dedicated to the memory of Pat Michaud.





in Scorpius. Tom wanted to see some globular clusters, so I clicked on "Show Deep-Sky," and the chart filled with dozens of symbols. I clicked on one beside Antares, and the data bar above the chart told me it was M-4, just as I had expected. I pulled down the Position menu, then clicked Move To. The Mac bonged twice. Stepper motors squealed into action; a moment later Tom called out, "That's a bright one."

I pulled down the Position menu again, and clicked Auto Position. Henceforth the telescope would automatically go to whatever object I clicked without having to be told to move.

"Here comes M-80," I warned, "watch out." Click. Bong Bong. Bizzz, bzzwt, gug. "I see it," said Tom.

"Another. Don't know what this one is. Ready?" Click. Bong bong. Bizzz, bzuuw bzuuw bzuuw gug.

"This one's real dim," said Tom.

"It's 12.5 magnitude," I said, reading the numbers from the screen, "and 3.1 arcminutes diameter. Want another?"

"You look for a while." So I did.

Tom and I worked our way through Scorpius, Ophiuchus, and Sagittarius, concentrating on globular clusters, some faint, some bright, some all but invisible in the telescope, thirty or forty objects in ten minutes.

Then Tom started slipping in planetary nebulae. "Can you see this one?" he'd ask, "it's ten arcseconds and 11.8 magnitude. I would focus carefully, searching carefully outward from the field center. "Okay, got it." Bong bong. Bizzz, bzuuw, gug. "Five seconds and 13.1," he said. I looked, my eyes starting to water. "No dice, no wait, there's a fuzzy star that could be it" Bong bong. Bizzz, gug. "Three seconds," he said, "don't bother. I'll get another." Bong bong. Bizzz. "Fifty seconds and 11.5," he called off. "Got it," said I.

The marvelous part of the Mac interface is that it's so simple. Two cold and tired people found dozens of objects. Objects I would never have bothered with -- and probably not have been able to find -- paraded through the eyepiece before my eyes. I saw extended objects like Barnard's galaxy (NGC 6822) that overfilled the field and tiny planetaries I would have found only after an extended search. They were ease to locate because I knew each object was going to be nearly dead-center in the field. The worst problem I had as an observer was that my eyes kept watering from so much concentrated looking.

The Mac interface also keeps the sky in front of the observer. I found it easy to glance up from the stars on the screen to the stars in the sky and see where among the stars the object lay. This doesn't happen with coordinates.

The magnificent part is that the program's output is a "go to" command string sent to the telescope controller over a serial communications link. With a little standardization, Tom's Mac could drive the multi-thousand-dollar Celestron/Simmons computerized telescope or David Gedahlia's $200 motorized Dobsonian equally well. It's an exciting prospect.

I was very tired now, so I thanked Tom for an incredible experience and tottered off to my warm sleeping bag.

The grounds emptied swiftly the next morning; by eleven there was hardly anyone left. I spent an extra day in the mountains holed up in a motel room writing this article on my NEC 8201 portable computer. (Yes, I still use it and I still love it!) It snowed that night. The next morning I flew back to Milwaukee.

-- Richard Berry

■

A Foucault Jest

I first caught the mirror maker's bug thirty-seven years ago at the tender age of fourteen. My symptoms started with a mild attack of 4" f/8. Since then I have been stricken with all the f/ numbers and diseases -- sorry, I mean diameters -- up to 16", and my sufferings have included migraine -- sorry, I mean Cassegrain -- and various side effects, including a bout of Schiefspiegler off-axis reflection. In recent years, direct from America, I contracted Dobsonianitis coupled with an itchy aperture madness causing my specula to grow progressively larger. American mirror makers who have suffered from a similar list of afflictions may find some comfort in a little rhyme I have penned.

Reflections by a Mirror Maker

Two discs of glass, abrasive powder,
Rubbed together, hour after hour.
Into a curve, frosted and crude,
Then polished on pitch, with the aid of rouge.

A slit of light, between two razor blades,
Knife edge plus practised eye, to judge the shades.
The Mirror Maker pits his skill,
To figure imperfections away to nil.

Until not even, a wave of light,
Reveals flaws, to human sight.
Then! and only then! in his experienced eyes,
Does he pronounce his mirror, "Parabolized."

How Old Is the Telescope?

As a research historian, author, museum curator, and telescope constructor, I am, to say the least, very dubious regarding the date given for the invention of the telescope. It is generally accepted that the spectacle maker Hans Lippershey (or perhaps his children) discovered by accident in 1608 that, with two convex lenses held apart, the church spire appeared much larger and then promptly constructed a telescope with two such lenses mounted in a tube. Galileo, hearing of this, constructed his first telescope in an evening using ready-made lenses he already had to hand (only his later instruments were entirely his work). Two interesting points arise: one being just how simple it is to construct a crude yet functional telescope using simple lenses and the other that by the early 1600s such lenses were to be readily found in many of the richer homes.

Just how long then had such spectacle lenses been available?

Spectacles consisting of a stiff leather cap containing two convex lenses were being produced as early as 1250, over seven hundred years ago. Bearing in mind that all one has to do to discover the simplest of tele-

scopes is to hold two such lenses of suitable focal lengths in line with the eye and a distant scene, the mind boggles. Are we really to believe it took more than three hundred years, until 1608, for someone to do this?

Such an assumption is an insult to human intelligence. I'm convinced that soon after simple lenses became readily available the telescope followed. Crude telescopes were not only feasible, but were possible, at least seven hundred years ago.

I wonder, can written history support an earlier invention date than 1608 for the telescope? William Bourne, writing around 1580, states that the researches of Digges and Dee could easily be put into practice and "that it is likely" and "true to see a small thing, of very great distance." Bourne himself wrote in 1578 a treatise on optics, describing the arrangement of lenses and mirrors for magnifying distant objects. But what were the researches of Digges and Dee he referred to?

In **Pantometria**, published in 1571, Digges wrote that his father, using proportional glasses situated at convenient angles, had been able to declare over a distance of 7 miles "what hath been doon at the instante in private places." He also, according to his sons, read out the details on coins and medallions thrown on the grass some distance away by using the same apparatus.

Page 132 in the **Lexicon**, a dictionary compiled in Peru in 1540 by Domingo de San Tomas, a Dominican monk, and published in June 1560, giving equivalent Inca/Spanish words, translates the ancient Peruvian word Quilpi, an article made by the Incas, into *anteojos con espejuelos curvos*. The *espejuelos* are concave or convex mirrors or lenses. *Anteojos* means spy-glasses or spectacles. Quilpi, therefore, translates as an optical instrument for looking into the distance - or, if you prefer, a telescope. It should also be noted that *Quillaquiz* means a planet or cosmic system. The roll of honour includes Hans Lippershey, Digges, Dee, Jansen and Metius - yes, there are many other candidates for the title "Inventor of the Telescope."

For instance, at the museum I have a copy of a picture taken from a fifteenth-century English manuscript that shows Pythagoras looking through what appears to be a telescope and an illustration by Matthew Paris from a fourteenth-century English manuscript, showing Euclid looking through what could well be a telescope. What's more, translated, the caption reads - "Euclid (300 B.C.) observing the moon and stars with a dioptra." Don't be too surprised if this word dioptra has a familiar ring to it. "The dioptre is still the measurement of power given to simple close-up lenses used in photography, and if you look up dioptric and associated words in the dictionary, you will find the following explanation: "assisting the sight in the view of distant objects."

Of course I must advise caution, because it is dangerous to read too much into the quirks of history that I have referred to. Even so, I can't help feeling that the telescope was invented long, long before 1608. Perhaps TM readers would like to tell me their thoughts on this controversial matter.

I would also like to take this opportunity to say a fond hello to the many American tourists who over the years I have shown around the Abbey, part of which is over 1,300 years old. Most of these visitors come to see the tombs of their ancestors -- the Norwoods and Cheyneys -- and as a result became my friends and correspond regularly.

Brian Slade, F.R.A.S.
Curator
Minster Abbey Gatehouse Museum
"Santa Maria"
8 Queens Road
Minster, Isle of Sheppey
Kent ME12 2HD
England

■

Letters

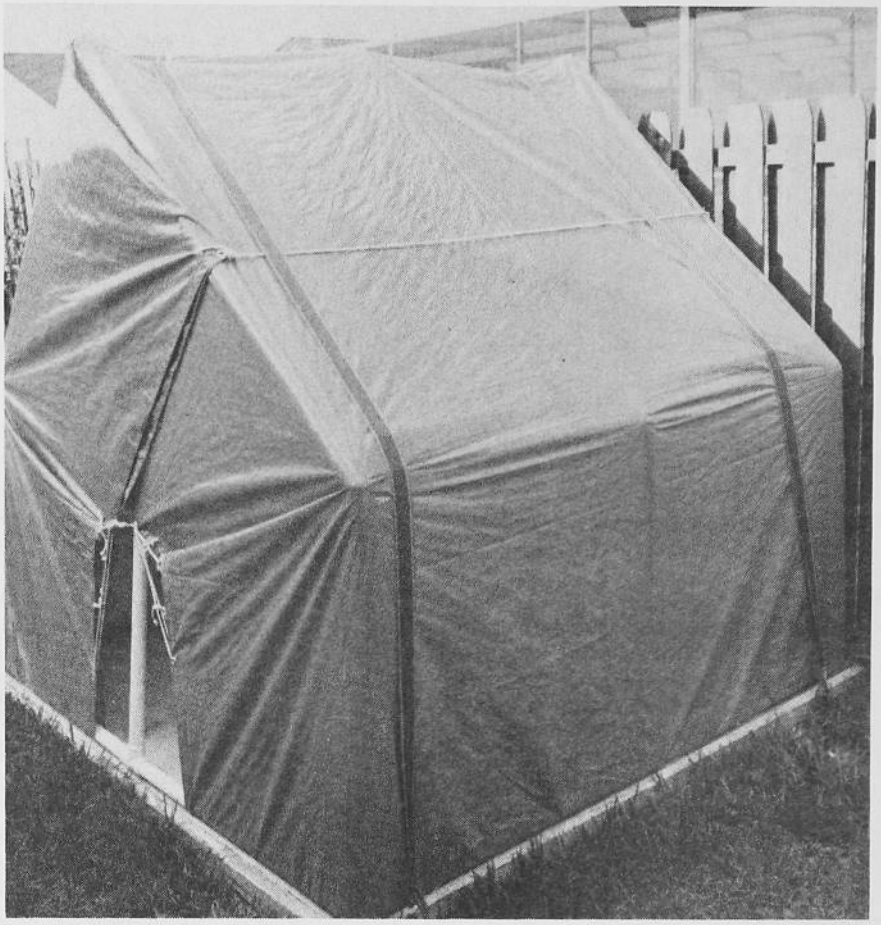
PVC Pipe Observatory

I recently constructed an inexpensive house for my new 10-inch Meade LX-5. The PVC pipe cost me $71.56 and the cover is a K-Mart special tarp that cost $16.97.

I poured a cement pad and ran electric power to it. The base is 6'9" x 6'9". The height of the house is 6'5". The straps slung over the house are made of replacement webbing for garden chairs with a swivel clasp attached to each end. I had to strap down the unit because at 56 pounds total weight, the building is likely to blow away unless something is holding it down.

When using the scope, I tip the house on its side, so setup is very simple and fast. For those in more northern locations the unit would have to be made stronger, perhaps by using additional cross members.

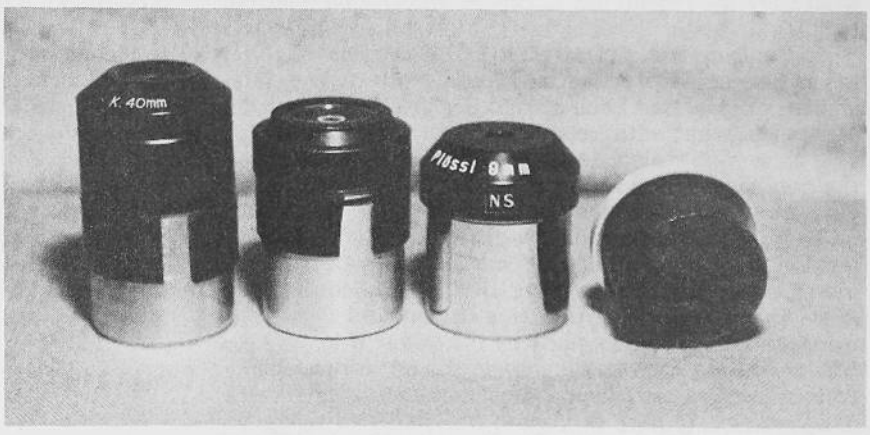
Chuck Healy
1620 Cinnamon Lane
Dunedin, IL 33528



Easy Parfocalizing

Dear Sir / I'm enclosing a photo of a mixed set of eyepieces I "parfocalized." As you can see, I simply cut up some plastic 35mm film canisters. I used an Xacto hobby knife while supporting the inside of the canister with a pencil. The plastic rings have enough spring that they need not be glued on. The cap and top part of the canister make handy dust covers for 1.25" focusing mount and, with a small hole drilled in the center, facilitate final collimation.

Robert E. Perry
RR #3 Box 864
Collinsville, IL 62234



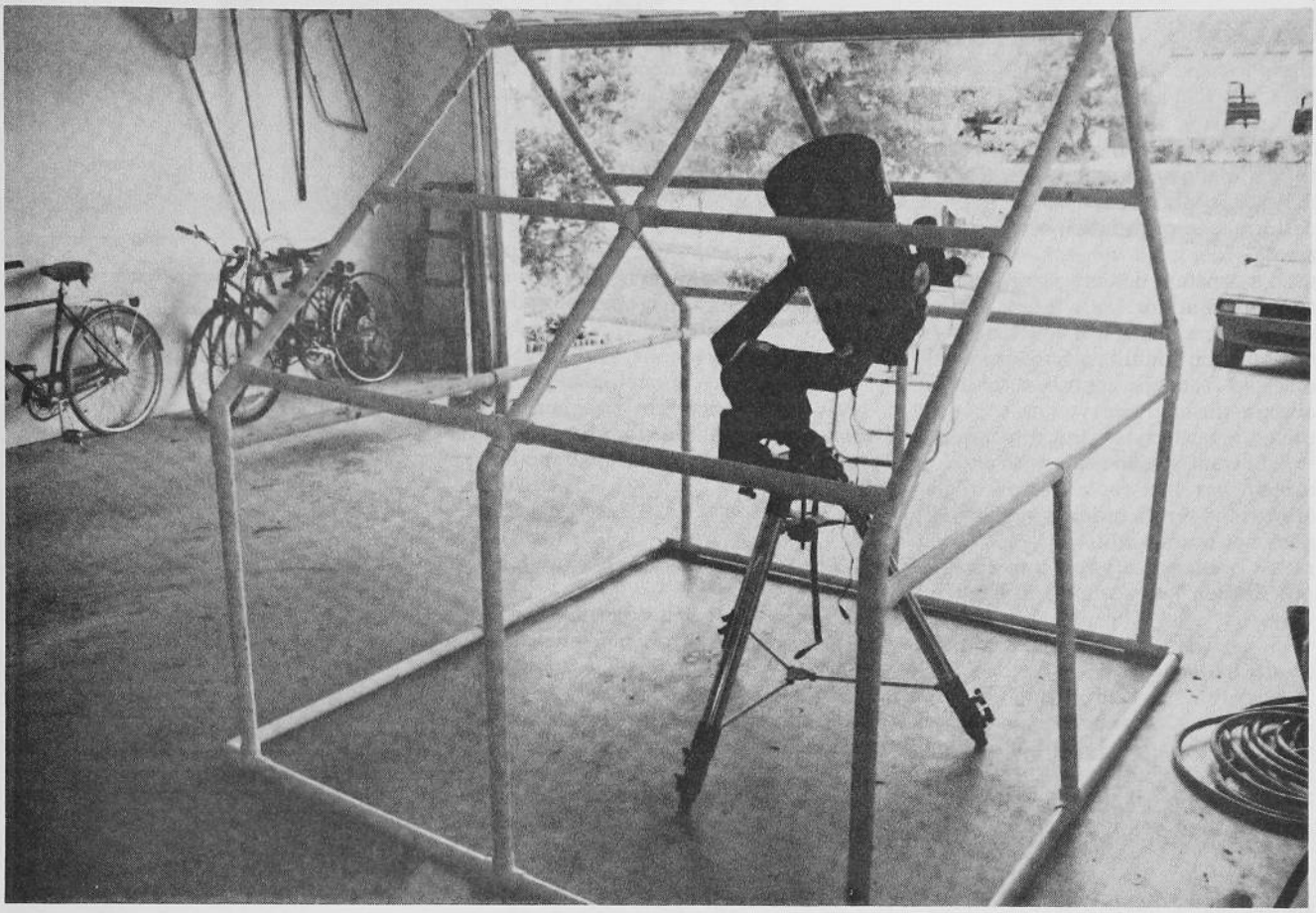
Gospel According to Saint Russell

Dear Sir / In the beginning there was the Light, and the Light was beheld by the privileged few who worked in the big domes or had the wherewithall to own a Clark. And they saw the Light and it was good. Then Saint Russell came down from the Tundra and found the masses yearning to see the Light and learn of its secrets, and he founded the Springfield Telescope Makers and said "I will make you pushers of glass." And "Unk" Ingalls saw the telescope makers and began to preach of the wonders he had seen, and this begat the ATM trilogy, and many others followed.

And the "Celestars" and "Questrons" appeared, and computers and gadgets proliferated, and the Light became harder to see, except for the chosen followers, the TMs, who quietly kept the vision of Saint Russell alive and deign to spread his good news across the Cosmos: the Light is still there for those who are willing to seek it.

Amateur astronomy today is riding the swell of interest left in the wake of Halley's Comet; that's the good news. The bad news is that not enough people are aware of what our wonderful hobby (or is it a life's work?) has to offer. Very few people, especially in urban areas, ever take notice of the sky above them, let alone appreciate the marvels that are there. It is up to us, the disciples of Saint Russell, to spread the word. Let me tell your readers a little about what we're doing, so they can perhaps do likewise.

We are fortunate here in Washington, D.C., to have such institutions as the Smithsonian, the U.S. Naval Observatory, and NASA at our disposal. The local amateur groups have a rich trove of guest speakers to choose from, the Observatory has a weekly night tour, and there are many regional parks that are willing to host public star parties. These events are always well-attended. I have seen one thousand people turn out for a Halley Watch event in 15° weather (fortunately, we had twenty-four telescopes for that one). I hosted



one program several years ago where over a hundred people gathered during a thunderstorm to see a slide show on the stars in an outdoor amphitheater ("It'll clear. We'll wait!") The interest is there for us to tap.

The interest is also "out there" in the rest of the country. In the past year I have been fortunate to go "on the road" with the Smithsonian National Associates to lecture on the joys of amateur astronomy. I call the program "Telescopes for Everyone." My "show" consists of slides (a mix of my own images and the best from NASA) and a demonstration of a home-built 8-inch Newtonian telescope (which travels in a crate that resembles a magician's). The scope is on a simple Dobsonian-type mounting and was built in a few weeks of evening work (see *TM#26*, p.9).

The slides show people what they can expect to see with an instrument of that size, and the NASA shots help to jog their imaginations into overdrive. I hand out plans for the scope and a list of suppliers and resources, and I even have a 6-inch mirror and tool for those who want to try their hand at a few "wets" of glass-pushing. If the weather's clear, we go out and look at the Moon, whatever planets are handy, or a nice double star like Mizar or Alberio.

The response is tremendous! Even though there is a nominal charge for the program every one I have done has had a great reception. I have received letters and pictures from participants who have built the telescope and begun their personal tours of the universe. I know of a dozen kids who've built the 'scope (yes, with a bit of help from a parent) and won prizes in science fairs. It is a very gratifying experience.

And that, perhaps, is the best thing about amateur astronomy. People share their experience with others and the cycle starts anew. It should be the responsibility of every amateur to try to show as many people to the Light as possible. Scout troops, school groups, local park programs, club meetings, whatever.

Saint Russell left us a legacy of love and respect for the stars, and it is up to us to pass this on. We all love astronomy and it means something to us; it is a part of our lives that can be very emotional and personal, and when we live it or talk about it, it comes straight from the heart. Sure, there are those nights when I have to toddle off to Rixeyville and get my "fix" of deep-sky gazing, but there are also those times when I'm compelled to share the sky with others.

Geoff Chester
4239 S. 32nd Street
Arlington, VA 22206

Gleanings for Apodizers

Dear Sir / Here's some more information related to my apodization article.

I based my calculation of Edberg's most elaborate screen on the assumption that Edberg used a generic window screen. I might add that Edberg does not agree with my replacing the exact, very complicated pupil function with a constant lower transmission coefficient. We are corresponding about this and hope to come agreement soon.

When I argued that a neutral density filter explanation was consistent with the reduction of seeing difficulties, I said a filter that extended beyond about half the radius would be adequate. What I meant to say was that any continuous density filter serves in this regard, but if you want a filter that might occasionally reduce the diffraction rings, start it at about half the radius.

It is unfortunate I used the word "cure" in reference to using these filters to deal with seeing difficulties. Perhaps I should have said "modify favorably."

I realize that perhaps I gave the wrong impression when I was explaining why window screen is okay for use in these

Letters

filters. When I was saying how interference between all the holes in the grating gave the same resolution as an unobscured aperture, I was using the approximation of a uniform screen. For the annular shapes dealt with here, the performance of the total screen in the zeroth order is no worse than if we had used a constant density screen in each annulus. But for both filters (one of window screens, one of constant lower transmission annuli) we have more light diverted from the central disk. If you obscure the aperture, you must pay the price, regardless of your technique. What I wanted to indicate with window screen was that for a narrow region around the zeroth order image, it really does not matter which type of obscuration we employ. But any form of obscuration will scatter that light in a way that won't be objectionable for what we wish to view and to achieve locally better conditions. By the way, it is the periodic nature of window screen that allows us to use it. A random screen places the greatest amount of scattered light on top of the image. Although I have done no calculation, I think this also applies to an inward-spiking apodizer that was suggested in Leonard's 1954 article. Screens are not used because they happen to be handy — they also have very nice properties.

Perhaps I spoke too briefly about the High Ring screen (HRS). I just didn't want to give people false hopes. The theoretical calculation works very well in small (less than 25 percent) obstructions, but it gets increasing difficult to keep that extra strong out ring sufficiently small for large secondaries. The 30 percent HRS calculation illustrates this. The outer ring was dept only 3 dB below the first ring. This was caused by my trying too hard to get the peak of the first ring to reconstruct the peak of the unobstructed pattern. This I did fairly well — it doesn't start deviating strongly until the outside of the first diffraction ring. I pointed out in the article, though, that if you were willing to yield a little on this, you could get that ring down. The way you do this is to increase the width of the bright ring and perhaps increase the transmission of the shaded portion somewhat.

As far as the small secondary is concerned, the detailed data for the 20 percent HRS is: radius obstructed, 0.1; radius that shading begins, 0.1414; shaded transmission coefficient, 0.5. At the risk of giving people the wrong impression, it seems that I have "piled-up" enough transmission right next to the diagonal to just fill in the hole. Like a stage magician, however, I can't fool everybody at every angle and at the second or third diffraction ring, the deception breaks down. The OTF of this screen is disappointing, which indicates the planetary uses of this filter are limited. The wide gap between the first diffraction ring and that extra strong outer one should make this filter interesting to double star observers, however, allowing them to shove aside a gap for stars of a certain separation. Of course, apodization has long been used for double stars. Cutting a square mask and orienting it like a baseball diamond (with the line of stellar separation between first and third base) has been a standard technique for years. This is, in effect, a one-dimensional apodizer.

Dick Suiter
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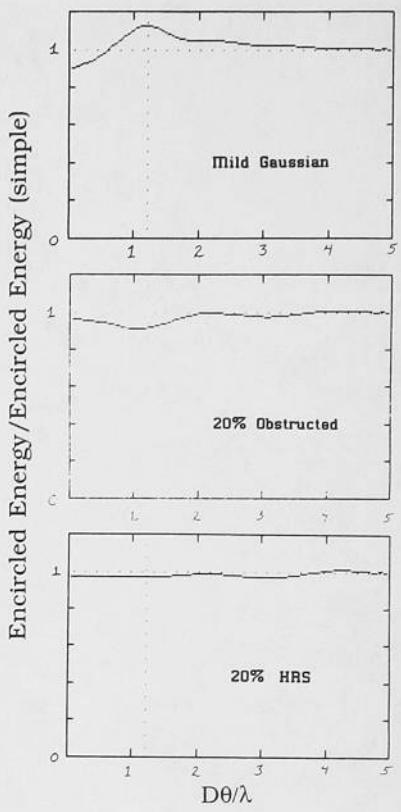
Panama City, FL 32405

P.S. During a recent experiment where I tried to cut inward-pointing needlelike spikes (such as Art Leonard suggested in his 1954 article in *Scientific American*), it seemed as if there was an inner region where effects directly attributable to the spikes were excluded. The net effect looked a lot like a very strong halation ring. Perhaps I was too hasty in dismissing the technique. Still, manufacture of such a device is nearly impossible and justified only if there is some need for a linearly varying transmission coefficient. The difficulty can be estimated by noting that the base of each inward pointing spike probably should be a *Maximum* of 1/8 of an inch with the spike narrowing from there. Possibly the method might be of some interest when used to taper-to-zero (I like the word "feather") the outer zone of a conventional screen-type apodizer. A feathered outer zone will drop the transmission somewhat less abruptly than a step-screen apodizer. More trials are needed.

I've also come up with a method of estimating the width of a strand that is less crude. Make a 2-inch projection slide from window screen material and measure the projected image of it rather than the real thing. NOTE: Don't let fiberglass screens sit illuminated in the gate long enough for the coating plastic to catch fire. A more refined procedure (and a safer one) is to use a photographic enlarger to do the projected cell.

An error occurs when I stacked up one or more layers of screen. The error is caused by the fact that once an area is screened to darkness, covering it again makes it no blacker. Therefore, multiplying the transmission of a multiple layer screen is an approximation. (The correction adds a few percent to each layer of screening material.) My



measurements were so crude, however, that such an error correction would imply spurious precision. A person doing accurate projection measurements might want to take it into account, however.

P.P.S. I have added another procedure to my program APODIZE. It calculates the encircled energy of the diffraction pattern and compares that encircled energy with that of a simple aperture. The graph "Mild Gaussian" illustrates that in a small region around the outside of the central disk (the disk edge of a simple aperture is denoted by a vertical line), the apodized aperture actually has a larger fraction of the total energy encircled than a simple aperture does. The figure entitled "20/ obstructed" shows the oscillatory behavior of an obstructed aperture while "20/ HRS" shows the more regular appearance of the obstructed aperture to which a High Ring Screen has been applied. The total energy is normalized to its value at D×theta/wavelength = 5. If the pattern still has significant changes there (or the encircled energy has a significant slope), this can lead to an error in the relative encircled energy.

People who are interested in obtaining a copy of the enhanced program should write directly to me at the address above. ■

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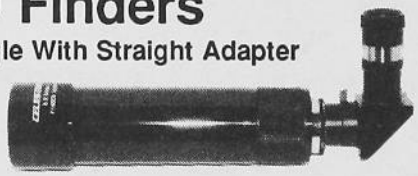

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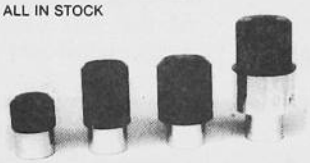

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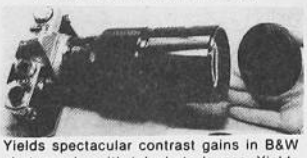

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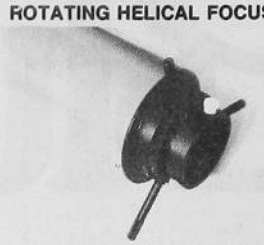

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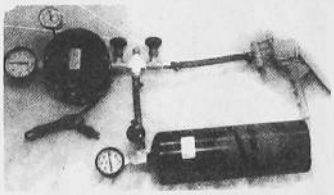

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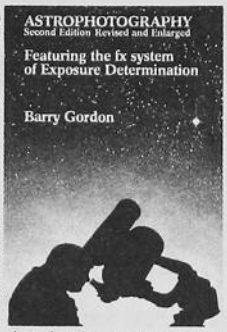

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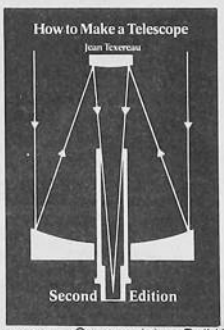

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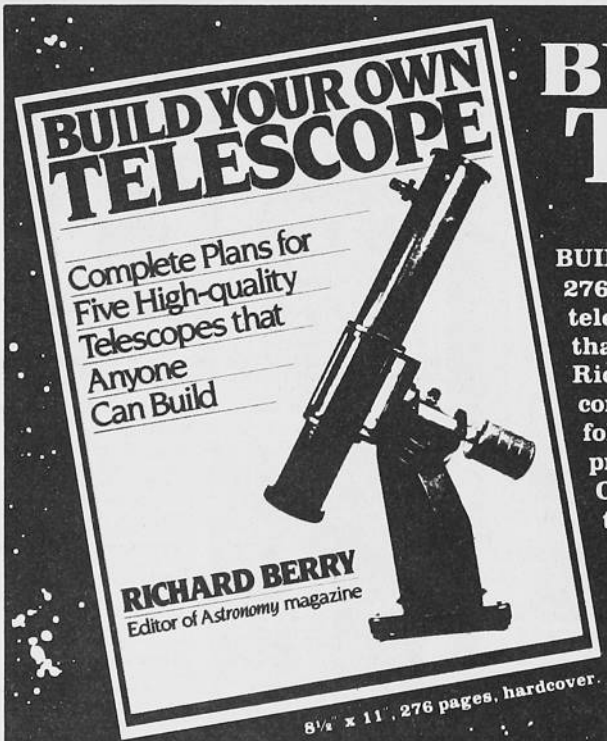

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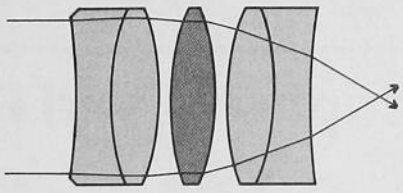
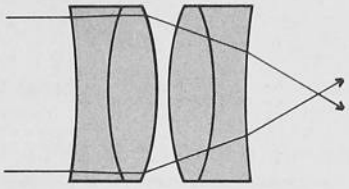
In 1984, Meade engineers set out to design the finest eyepieces and Barlow lenses—bar none—ever made available for modern telescopes. Specifications called for an unprecedented order of sophistication. Computer optimized design. Special low dispersion glasses (some not even available until recently). And the very latest in coatings technology. Not surprisingly, the resulting Meade Series 4000 is nothing less than a new performance standard in professional optics. The eyepieces and Barlows you would expect from the World's leading manufacturer of astronomical telescopes for the serious amateur.

Design Specifications: Meade Series 4000 eyepieces yield the widest possible fields of view, consistent with pinpoint edge-of-field sharpness and long eye relief, and yet with extremely low astigmatism, spherical aberration, and off-axis color. Incorporating 7-layer multi-coatings and edge-blackened optics for optimal image contrast, these sophisticated 5- to 8-element designs permit levels of optical corrections virtually impossible to achieve with eyepieces of fewer elements. The polished chromed-brass barrels are threaded for standard filters, and, where practical (see table), eyepieces and both Barlow lenses are parfocal, allowing eyepiece interchangeability without refocusing.

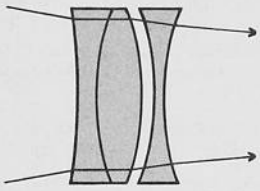
Eyepiece Groups: Eighteen focal lengths in the three Series 4000 eyepiece groups permit precisely the right eyepiece for any application. Whether your telescope is an f/4 Newtonian, an f/10 Schmidt-Cassegrain, or an f/16 refractor,



Meade 5-element Super Plössl design: the central lens element enables significant reductions in chromatic aberration and edge-distortions over other premium Plössl designs.



Other premium Plössls: include only the traditional 4-elements.



Meade Series 4000 Barlows: 3 elements, air-spaced, instead of the standard 2 non-air-spaced elements.

Series 4000 Eyepieces and Barlows

Super Plössls (5-elements)	APPARENT FIELD	BARREL DIA.	PARFOCAL
6.4mm	52°	1¼"	Yes
9.7mm	52°	1¼"	Yes
12.4mm	52°	1¼"	Yes
15mm	52°	1¼"	Yes
20mm	52°	1¼"	Yes
26mm	52°	1¼"	Yes
32mm	52°	1¼"	Yes
40mm	44°	1¼"	No
56mm	52°	2"	No
Super Wide Angles (6-elements)			
13.8mm	67°	1¼"	Yes
18mm	67°	1¼"	Yes
24.5mm	67°	1¼"	Yes
32mm	67°	2"	No
40mm	67°	2"	No
Ultra Wide Angles (8-elements)			
4.7mm	84°	1¼"	Yes
6.7mm	84°	1¼"	Yes
8.8mm	84°	1¼" & 2"	Yes
14mm	84°	1¼" & 2"	No
Barlow Lenses (3-elements, air-spaced)			
#140 2X Telenegative Amplifier		1¼"	Yes
#142 2.8X Telenegative Amplifier		1¼"	Yes

Meade 2" Mirror Diagonal: For attachment to Schmidt-Cassegrain telescopes, the 2" Mirror Diagonal permits use of Series 4000 eyepieces with 2" barrels. The 1/10-wave-flat Pyrex mirror, manufactured at the Meade Costa Mesa optical facility, is multi-coated with enhanced aluminum for maximum reflectance. An adapter for 1¼" eyepieces is included.

Where To Buy: Meade Series 4000 eyepieces and Barlows are available from over 600 authorized

Meade®: First in Eyepieces too.

its performance will benefit by using these incredible oculars:

Super Plössls: With 5 optical elements rather than the traditional 4, Meade Super Plössls provide a 40% improvement in corrections for chromatic aberration and edge-distortions over any other premium Plössls. Best for general observing at moderate cost, the Super Plössl eyepieces are perfect optical complements for the Series 4000 air-spaced Barlows, below. Try the 56mm on your 8" Schmidt-Cassegrain for an actual field of over 1.4° at 36X!

Super Wide Angles: These 6-element eyepieces, with their 67° fields, offer exquisite wide-angle images at low to medium powers, ideal for star fields, galaxies, and other deep-space phenomena. Focal lengths with 1¼" barrels yield extremely high-resolution, high-power lunar and planetary images when combined with one of the Series 4000 Barlows.

Ultra Wide Angles: The ultimate in modern eyepieces, Meade 8-element Ultra Wide Angles permit extreme image fidelity and sharpness over an amazing 84° apparent field: for moderate to high power applications, no other eyepieces come close. A magnificent optical match with Schmidt-Cassegrains and fast Newtonians.

Series 4000 Barlow Lenses: The most sophisticated Barlows ever developed for commercial telescopes, these 2X and 2.8X Telenegative Amplifiers include 3-element, air-spaced, multi-coated optics, unmatched in image resolution and color correction. Both models optically complement the Series 4000 eyepieces, while significantly enhancing the performance of other eyepieces as well.

Meade dealers in the U.S.A. and Canada. Call us toll-free (see below) for your nearest dealer.

Prices: Notwithstanding their performance standards and optical sophistication, Meade Series 4000 eyepieces and Barlows are priced very competitively with other premium oculars and Barlows.

Warranty: All Series 4000 systems are covered by the Meade Limited Lifetime Warranty—the most extensive in the industry. See the Meade catalog for details.

New 1986 Meade General Catalog 86-R: $3.00

Just-published, the new Meade 1986 General Catalog includes complete information on the full range of Meade astronomical products, along with a supplement on **"How To Choose Your Eyepieces."** Send $3.00 for your copy.

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1-800-854-7485

From all other areas, including California, call direct: **(714) 556-2291**

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